INSTRUCTION MANUAL
MODEL 627
13 MHz FUNCTION GENERATOR

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CONTENTS

SECTION 1	SPECIFICATIONS
SECTION 2	OPERATING PROCEDURE
SECTION 3	CALIBRATION
SECTION 4	THEORY OF OPERATION
SECTION 6	PARTS LIST
SECTION 5	SCHEMATICS AND COMPONENT LOCATORS

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SECTION 1

SPECIFICATIONS

INTRODUCTION

The Model 627 is a 13 MHz Function Generator with the following features:

GPIB PROGRAMMABLE - A comprehensive interface system which includes Service Request and remote triggering (IEEE-488).

FRONT PANEL - All instrument parameters and operating modes are easy to set up by pushbutton.

WAVEFORM VERSATILITY - Variable Symmetry, Haver style and Inverted waveform capabilities make a variety of waveforms possible including ramps and pulses with variable duty cycle.

AUTO CALIBRATION - Self measurement of frequency and symmetry allows the instrument to make corrections to calibrate these parameters itself. A frequency tracking Cal mode locks the frequency accuracy to within .1% of setting.

NO INTERNAL ADJUSTMENTS - A complete calibration of all parameters may be made without ever opening the case of the instrument. The calibration routine may be performed manually with the front panel or remotely over the GPIB.

NON-VOLATILE MEMORY - Current instrument settings are retained and calibration constants are stored in non-volatile memory.

ERROR INDICATIONS - LED's flash to indicate illegal combinations of programmed settings.

SPECIFICATIONS

WAVEFORMS

Sine, Triangle, or Square.
Regular or Haver version of three basic waveforms.
Invert switch for all waveforms.
DC when untriggered.

FREQUENCY (Note 2)

0.1 mHz to 13 MHz in 9 overlapping ranges.

Resolution:
3 1/2 digits, 1-1300 display counts on each range.
Accuracy with Cal 2 ON (Frequency tracking):
±0.1% of setting, 1 Hz to 13 Mhz.
Accuracy with Cal 2 OFF:
±(1% of range + 1% of setting), .13 Hz to 1.3 MHz.
±(2% of range + 2% of setting), 1.3 MHz to 13 MHz.
Stability:
±.05% for 10 minutes.
±.25% for 24 hours.
VCF Input:
600 ohm input impedance.
5V for a 1300:1 frequency increase.
Additional rear input jack optional.

SYMMETRY (TIME)

Variable from 5% to 95% (Frequency is limited when Symmetry is set to value other than 50%).

Resolution:
1%.
Accuracy:
±(1% + 10 nsec) at 50% Symmetry setting.

AMPLITUDE

.01 V to 10 V Pk-Pk into 50 ohms, double into high impedance loads.

Resolution:
- .01 V, over full range.
- .001 V, .01 V to 1 V.

Accuracy at 1 KHz:
- ±2%, 1 V to 10 V.
- ±3%, 10 mV to 1 V.

Stability:
- ±.05% for 10 minutes.
- ±.25% for 24 hours.

Flatness, Sinewave:
- ±.1 dB to 100 KHz.
- ±2 dB to 13 MHz.

AM Input (Optional):
- 600 ohm input impedance.
- Amplitude varies proportional to input voltage.

OFFSET

-5 V to +5 V into 50 ohms, double into high impedance loads.

Resolution:
- .01 V, over full range.
- .001 V, -.5 V to +.5 V.

Accuracy:
- ±3%, .5 V to 5 V.
- ±4%, 0 V to .5 V.

WAVEFORM CHARACTERISTICS (Note 2)

Sine, at 10 V Pk-Pk:
- Distortion: ±.5%, 10 Hz to 100 KHz.
- Harmonics: < -40 dB, 100 KHz to 1 MHz.
  < -30 dB, to 13 MHz.

Triangle Linearity, 10% to 90% of waveform:
- > 99%, 0.1 mHz to 100 KHz.
- > 95%, to 13 MHz.

Square wave at maximum amplitude into 50 ohms:
- Transition Time: < 20 nsec.
- Overshoot and Ringing: ±5%.

OUTPUTS

Main:
- Dual output jacks switchable front or rear.
- Output Impedance: 50 ohms.
- Protected by clamp circuits and fuses.

Sync:
- Dual output jacks front and rear.
- TTL levels: 0 V to 3.5 V.
- Output Impedance: 50 ohms.
- Transition Time: 8 nsec.

TRIGGER MODES

Run:	Free running waveform.
Gate:	Free runs when triggered.
Trigger:	Single cycle when triggered.
Inhibit:	DC only, generator locked out.

TRIGGER SOURCES

Manual: Front panel pushbutton.

External Trig In:
- DC Coupled.
- Input Impedance: 1 K ohm.
- TTL Level: 1.4 V.
- Additional rear input jack optional.

GPIB Triggers:
- Group Execute Trigger (GET) single shot command.
- Steady State GPIB trigger setup commands.

GPIB PROGRAMMING

Subsets of IEEE-488:
SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, and E2.
All instrument settings are programmable.

DISPLAY

3 1/2 digit yellow LED display.
Yellow LED annunciators.

POWER REQUIREMENTS

Voltage: 100, 120, 220, or 240 VAC.
±10%, switch selectable.
Frequency: 50-60 Hz.
Power Consumption: 55 VA Max.
Fuse: Type 3AG Slow Blow.
3/4 A for 100-120 V.
1/2 A for 220-240 V.

ENVIRONMENT

Storage Temperature: -40 to +70 degrees C.
Operating Temperature: 0 to +55 degrees C.
Specifications Valid: +20 to +30 degrees C.

DIMENSIONS

Height: 3.45 inches (8.9 cm).
Width: 8.7 inches (22.1 cm).
Depth: 14 inches (35.6 cm).
Weight: 7.0 lbs. (3.2 kg).

OPTIONS AVAILABLE

Electrical Options:

1. Rear Trig In and VCF Input jacks.
2. AM Input (rear).

Note: Options 1 and 2 not available together.

Mounting Options:

3. Rack mount brackets without handles.
4. Rack mount brackets with handles.
5. Centering plates for mounting a single instrument in the center of a 17 inch rack.
6. Side plate for mounting a single instrument on one side of a 17 inch rack.
7. Clamps for mounting two instruments together on a 17 inch rack.
8. Non-rack mount handles.

Note: For complete mounting kit, order one each of options 3 or 4 and one each of options 5, 6, or 7.

NOTES:

1. Specifications apply after a one hour warm up period.

2. Specifications for Frequency and Waveform characteristics are applicable only at frequencies from 10% to 100% of each frequency range.

3. Specifications subject to change without notice.

VERIFICATION OF SPECIFICATIONS

INTRODUCTION

To verify the specifications the following equipment is required:

OSCILLOSCOPE: DC to 100 MHz with differential comparator.

COUNTER/TIMER: .001 Hz to 20 MHz with time interval A to B.

HARMONIC DISTORTION ANALYZER: <0.1% residual distortion.

SPECTRUM ANALYZER: 100 kHz to 100 MHz.

Before verifying the specifications, turn on the instrument and allow it it warm up for one hour. Refer to Section 2 to verify the basic operation of the instrument. Perform a USER CAL 6 prior to checking specifications.

FREQUENCY ACCURACY

Set the instrument to the following conditions:

FREQUENCY	13 MHz
AMPLITUDE	10 V
OFFSET	0 V
SYMMETRY	50 %
MODE	RUN
WAVEFORM	SQUARE
HAVER	OFF
INVERT	OFF
AUTO CAL	OFF

Connect the OUTPUT, terminated into 50 ohms, to the counter/timer. Using CHART 1.1, set the frequency as stated and observe the indicated counter reading.

Turn on AUTOCAL 2 and repeat the above measurements checking that all frequencies are withiun .1% of setting. It takes several seconds for the frequency to stabilize at each setting. Skip the measurements below 1 Hz because AUTO CAL 2 does not work there.

627 SETTING	COUNTER READING MIN	MAX
13.00 MHz	12.48 MHz	13.52 MHz
01.30 MHz	1.014 MHz	1.586 MHz
1.300 MHz	1.274 MHz	1.326 MHz
0.130 MHz	.1157 MHz	.1443 MHz
130.0 KHz	127.4 KHz	132.6 KHz
013.0 KHz	11.57 KHz	14.43 KHz
13.00 KHz	12.74 KHz	13.26 KHz
01.30 KHz	1.157 KHz	1.443 KHz
1.300 KHz	754.1 uSec	784.9 uSec
0.130 KHz	8.643 mSec	6.930 mSec
130.0 Hz	7.541 mSec	7.849 mSec
013.0 Hz	86.43 mSec	69.30 mSec
13.00 Hz	75.43 mSec	78.49 mSec
01.30 Hz	864.3 mSec	693.0 mSec
1.300 Hz	754.1 mSec	784.9 mSec
0.130 Hz	8.643 Sec	6.930 Sec

CHART 1.1

FREQUENCY STABILITY

Set the controls as in FREQUENCY ACCURACY step with AUTO CAL off. Set the frequency to 2.000 KHz and record the counter reading. Wait 10 minutes and measure the frequency again. It should be within .05% of the previous reading. Wait 24 hours and measure it again. It should be within .25% of the first reading.

TIME SYMMETRY

Set the controls as in FREQUENCY ACCURACY step. Set the counter to measure time interval A to B. Set the counter trigger levels to the middle of the waveform. For each frequency in CHART 1.2, make the following calculation:

(Aup - Bdn) - (Adn - Bup)

The result should be less than the number in the chart.

627 FREQUENCY	SYMMETRY ERROR
13.00 MHz	11.54 nSec
01.30 MHz	25.38 nSec
1.300 MHz	25.38 nSec
0.130 MHz	163.8 nSec
130.0 KHz	163.8 nSec
013.0 KHz	1.548 uSec
13.00 KHz	1.548 uSec
01.30 KHz	15.39 uSec
1.300 KHz	15.39 uSec
0.130 KHz	153.9 uSec
130.0 Hz	153.9 uSec
013.0 Hz	1.538 mSec
13.00 Hz	1.538 mSec
01.30 Hz	15.38 mSec
1.300 Hz	15.38 mSec
0.130 Hz	153.8 mSec

CHART 1.2

AMPLITUDE

Set the following initial conditions:

FREQUENCY	1.3 KHZ
AMPLITUDE	10 V
OFFSET	0 V
SYMMETRY	50%
MODE	RUN
WAVEFORM	SINE
HAVER	OFF
INVERT	OFF

Connect the OUTPUT, terminated into 50 ohms, to the oscilloscope differential comparator. Use CHART 1.3 to verify the accuracy of peak to peak amplitude for all waveforms including INVERTED waveforms.

627 AMPLITUDE	MEASURED P-P AMPLITUDE MIN	MAX
10.00 V	9.80 V	10.2 V
05.00 V	4.90 V	5.10 V
01.01 V	.990 V	1.03 V
1.000 V	.970 V	1.03 V
0.500 V	.485 V	.515 V
0.101 V	98.0 mV	.104 V
0.100 V	97.0 mV	.103 V
0.050 V	48.5 mV	51.5 mV
0.010 V	9.70 mV	10.3 mV

CHART 1.3

OFFSET

Set the following initial conditions:

FREQUENCY	1.3 KHz
AMPLITUDE	10 mV
OFFSET	0 V
SYMMETRY	50%
MODE	INHIBIT
WAVEFORM	TRIANGLE
HAVER	OFF
INVERT	OFF

Connect the OUTPUT to the oscilloscope, terminated into 50 ohms. Use CHART 1.4 to verify the accuracy of the OFFSET.

627 OFFSET	MEASURED OFFSET MIN	MAX
5.00 V	4.85 V	5.15 V
0.51 V	.495 V	.525 V
.500 V	.480 V	.520 V
.050 V	48.0 mV	52.0 mV
.010 V	9.60 mV	10.4 mV

CHART 1.4

SINE DISTORTION

Set the following initial conditions:

FREQUENCY	1.3 KHz
AMPLITUDE	5 V
OFFSET	OFF
SYMMETRY	50 %
MODE	RUN
WAVEFORM	SINE
HAVER	OFF
INVERT	OFF

Connect the OUTPUT to the distortion analyzer. Measure distortion of < .5%.

Connect the OUTPUT to the spectrum analyzer, terminated into 50 ohms (unless the spectrum analyzer is already 50 ohms). Set the frequency to 1.3 MHz. Check that no harmonic is less than 40 dB below the fundamental frequency.

Set the frequency to 13 MHz. Check that no harmonic is less than 30 dB below the fundamental.

SQUARE WAVE

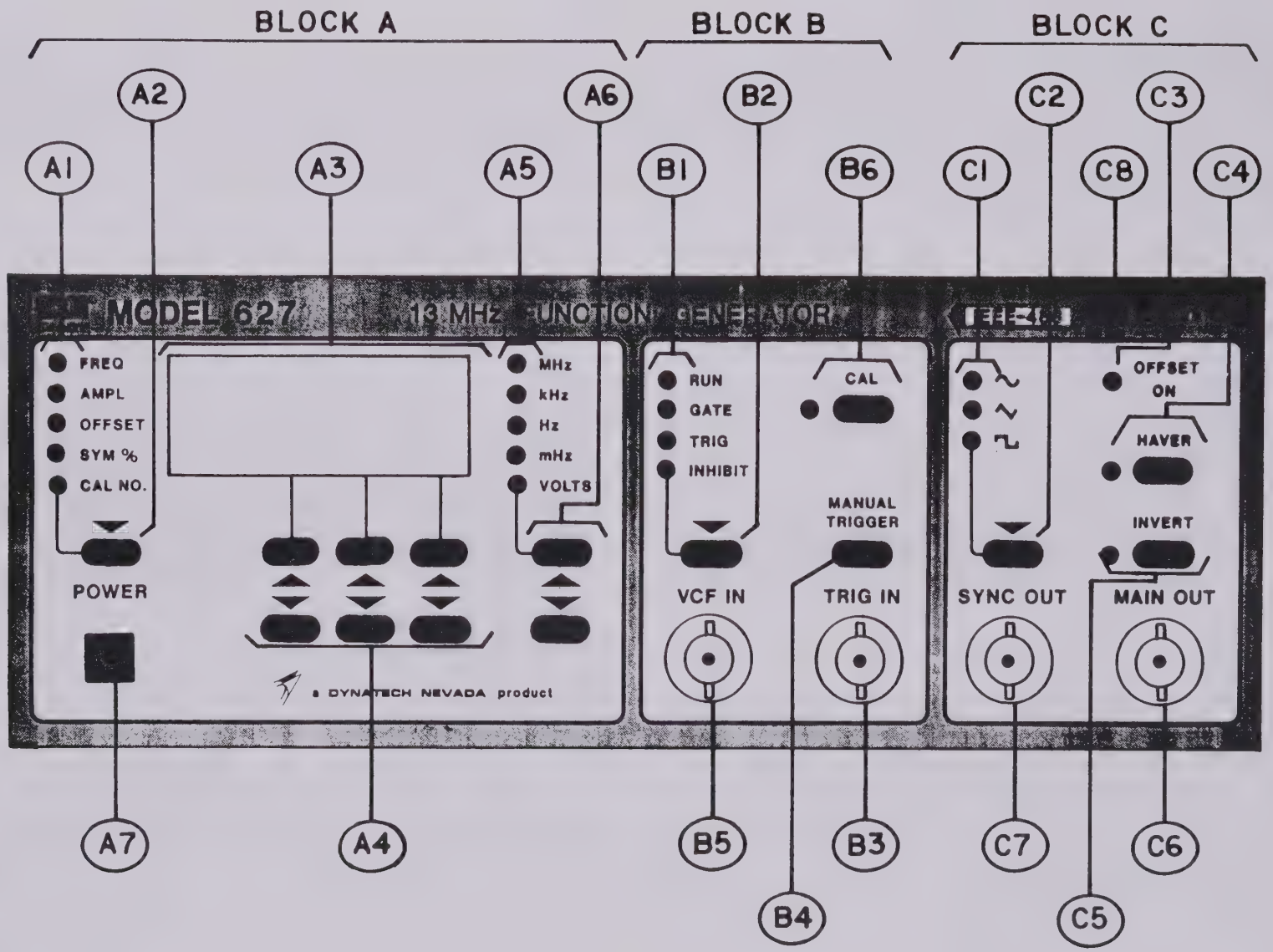
Set the following initial conditions:

FREQUENCY	2MHz
AMPLITUDE	10 V
OFFSET	OFF
SYMMETRY	50 %
MODE	RUN
WAVEFORM	SQUARE
HAVER	OFF
INVERT	OFF

Connect the OUTPUT, terminated into 50 ohms, to the oscilloscope. Measure the rise and fall times between 10% and 90% of the amplitude (±4.5 V) to be less than 20 nSec. Measure aberrations due to overshoot and ringing to be less than 5% of full amplitude (±.5 V).

SECTION 2

OPERATING PROCEDURE



627 FRONT PANEL FAMILIARITY

FIGURE 2.1

INSTRUMENT FAMILIARITY

This section describes the controls, displays, indicators, inputs, and outputs of the Model 627. It refers to Figure 2.1 and also refers to more detailed descriptions in sections listed in parentheses.

FRONT PANEL

The front panel is grouped into three blocks labeled A through C.

BLOCK A - NUMERIC PARAMETER DISPLAY

A1. DISPLAY SELECT LED's - Five LED's which indicate which parameter has been selected and is being shown on the numeric display.

A2. DISPLAY SELECT SWITCH - Switch to select the displayed parameter by stepping down through the five possible parameters. Some of the parameters are abbreviated on the front panel. They are defined as follows:

FREQ	-	Frequency
AMPL	-	Amplitude
OFFSET	-	Offset
SYM%	-	Per Cent Symmetry
CAL NO.	-	Calibration Number

A3. NUMERICAL DISPLAY - A four digit numerical LED display which reads the value of whichever parameter has been selected.

A4. NUMERICAL DATA ENTRY SWITCHES - Six switches which enter numerical data into the selected displayed parameter by incrementing or decrementing the number by ones, tens, or hundreds. The result includes carry into or borrow from higher digits as required. Each parameter is limited to a certain range of numeric values. If an entry would go beyond these limits it instead stops at the limit.

A5. RANGE/UNITS OF MEASUREMENT LED's - Five LED's which indicate the units of measurement of the displayed parameter, either frequency or voltage, except that symmetry and Cal No. do not have units. The symbols are defined as follows:

Mhz - Megahertz
kHz - Kilohertz
Hz - Hertz
mHz - Millihertz
VOLTS - Volts

A6. RANGE SELECT SWITCHES - Two switches which select the range for the displayed parameter by stepping up or down by a power of ten. Both the decimal point and the units LED's adjust to display the new range. Each parameter is limited to its own legal ranges. These switches do not affect Symmetry or Cal No. as these parameters have only one range and no units.

A7. POWER SWITCH - Turns on or off power to the instrument.

BLOCK B - TRIGGER

B1. TRIGGER MODE LED's - Four LED's which indicate the current generator trigger mode.

B2. TRIGGER MODE SELECT SWITCH - Selects the trigger mode by stepping down through the four possible modes.

B3. EXTERNAL TRIGGER INPUT BNC - Input jack for an external trigger signal.

B4. MANUAL TRIGGER SWITCH - Pushbutton for manually triggering the generator.

B5. VCF, VOLTAGE CONTROLLED FREQUENCY INPUT BNC - Input jack for a control voltage which may vary the Generator frequency.

B6. CAL SWITCH AND LED - Switch used to initiate or end a calibration routine. The LED indicates that a calibration is in progress. Also, when the instrument is in remote contol of the GPIB (Remote LED on), this button may now be used to return the instrument to local control of the front panel, if local lockout is not on.

BLOCK C - FUNCTION

C1. FUNCTION/WAVEFORM LED's - Three LED's which indicated the selected function or waveform. The functions are labeled by graphic pictures of the waveforms they represent, from top to bottom, Sine, Triangle, and Square.

C2. FUNCTION SELECT SWITCH - Switch to select the function by stepping down through the three possible waveforms.

C3. OFFSET ON LED - An LED to indicate that Offset is on, ie. that the numeric Offset parameter is not zero.

C4. HAVER SWITCH AND LED - Switch used to alternately select Haver or Non-haver waveforms. The LED indicates that Haver waveforms are selected.

C5. INVERT SWITCH AND LED - Switch used to alternately invert and re-right the waveform. The LED indicates that the waveform is inverted.

C6. MAIN OUTPUT FRONT BNC - Front jack for the main output.

C7. SYNC OUTPUT FRONT BNC - Front jack for the synchronizing signal from the generator.

C8. REMOTE LED - An LED which indicates that the instrument is under remote control of the GPIB interface.

REAR PANEL

1. POWER INPUT MODULE - Combination device which contains the AC power input jack, the line fuse, and the line voltage selector switch.

2. GPIB INTERFACE CONNECTOR - Connector with jack screws for a GPIB (IEEE-488) interface cable to remotely program the instrument.

3. MAIN OUTPUT REAR BNC - Rear jack for the main output.

4. SYNC OUTPUT REAR BNC - Rear jack for the synchronizing signal from the generator.

5. REAR EXTERNAL TRIGGER INPUT BNC (optional) - Input jack for a rear external trigger signal. NOTE: This jack may alternately be used for an optional AM input signal.

6. REAR VCF INPUT BNC (optional) - Input jack for a rear signal which may vary the Generator frequency.

7. TEST POINTS - Four pin jack test points for measuring voltages during the calibration procedure.

POWER

POWER INPUT MODULE

The Model 627 uses an integral module for AC input power which contains the power connector (IEC), fuse and fuseholder, and line voltage select switch. The fuse and select switch are normally shipped in the proper configuration for the destination country, but they should be checked prior to installation.

With the power cord removed from the connector, slide the plastic cover towards the left (looking at the rear panel) to expose the fuse. Remove the fuse by pulling the FUSE PULL handle. With this handle out, pull out the small PC board using a hooked instrument looped around the hole in the board. Select the nominal line voltage printed on the board (100, 120, 220, or 240) corresponding to the local line voltage. Orient the board so the selected number is at the top left position and push the board back into its slot. The selected number should now be the only number visible on the PC board. Check that the fuse is correct as specified on the rear panel label. Push back the FUSE PULL handle, reinsert the fuse and slide the cover back to the right. Plug the power cord into the connector. The instrument is now ready to be operated.

POWER-UP

Turn on power to the instrument by pushing in the POWER switch. On power-up the instrument will remember the conditions at which it was last powered and return to those settings.

INSTRUMENT SET-UP

The Model 627 may be set up to the desired operating conditions either by front panel switches or by remote control using the GPIB interface (IEEE-488).

Basic intrument set-up consists of the following steps:

1. Select Trigger mode.
2. Select Function (waveform).
3. Set Haver on or off.
4. Set Invert on or off.
5. Enter data for all applicable numeric parameters:

   Frequency
   Amplitude
   Offset
   Symmetry

6. Configure Main output jack if other than the front is used.

Once entered, numeric parameters remain current in the instrument even when they are not actively being displayed. Moving the display to another parameter in no way changes the parameters or the operation of the instrument.

In some modes of operation, certain parameters may conflict with others to create an illegal combination, even though each individual parameter is within its specified range. For example, too much Amplitude and Offset added together will clip the output power amplifier. The instrument allows numeric data entry within each parameter's speciied limits even though it may result in a setup error. In this way the operator is not required to enter parameters in any particular order. Whenever a setup error occurs, various LED's will flash to indicate what the error is. In addition a service request may be generated and the error type may be interrogated over the GPIB. See Setup Error.

FRONT PANEL

The four pairs of up/down switches and the three down select switches on the instrument feature a repeat action when held down. The display, trigger mode, and function select switches in addition will wrap around from bottom to top after reaching their limits.

GPIB INTERFACE

The Model 627 is remotely programmable by the industry standard General Purpose Interface Bus (GPIB) as defined by IEEE Standard 488-1978. All instrument settings are programmable. In addition, some features are operable only by the GPIB.

The instrument supports the following subsets of the interface functions of IEEE-488:

SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, and E2.

GPIB ADDRESS

The instrument's GPIB address is contained in non-volatile memory and therefore there are no address switches. The address has been preset at the factory to 10 but may be set to any number from 0 to 30 (decimal) by performing a Cal 9 routine. First, this Cal (9) must be enabled by setting the Cal Control Code to an appropriate number (2 through 5). See Cal Control Codes. With the proper Control Code entered, set the Cal No. to 9 and press the Cal button. The current GPIB address will now be displayed (with all display select LED's off) and the Cal LED will be on. Enter the new address as a decimal number with the numerical data entry switches. Push the Invert button to store the new address. The display will return to its previous state. The same procedure is used when only needing to read the address. Pushing Invert is the only way to exit the Cal 9 routine. The Cal 9 routine may not be entered remotely over the GPIB.

REMOTE/LOCAL FUNCTION

The instrument supports the GPIB Remote Local Interface Function (subset RL1) which includes Local Lockout. Use the standard GPIB protocol to control the various states.

In local, all normal front panel controls are operable and the instrument will ignore device dependent messages. The instrument powers up in local control.

In remote, all front panel switches are disabled except the Power, Cal, and Manual Trigger switches. The instrument will now accept and allow itself to be programmed by device dependent messages on the GPIB. The Remote LED will be on. If Local Lockout is also in effect, the Cal switch will be disabled. Otherwise, pushing the Cal switch will return the instrument to local control (ie. when under remote control, the Cal button acts like a Return to Local button).

PROGRAMMING: LISTENER FUNCTION

The main use of the GPIB is to program instrument settings. When in remote, and addressed to listen, device dependent messages will be received, interpreted, and converted to enter into the instrument modes and parameters. A message for programming consists of a string of ASCII characters containing the mnemonics for the desired commands and numeric data. Besides programming the instrument, the interrogate commands tell it to prepare a message which it will transmit when addressed to talk.

MESSAGE SYNTAX

An incoming message may be up to 128 characters in length. Spaces are ignored. A message must end either with a Line Feed (LF) or by asserting the EOI line with the last message character. Carriage Returns (CR) are ignored. A message contains one or more commands. The commands may be separated by spaces, commas, or semicolons, but they do not need to be separated by anything. A command may be in one of three formats:

1. Instruction mnemonic only.
2. Mnemonic followed by numeric data.
3. Mnemonic followed by numeric data followed by units of measurement.

No extra characters are allowed between parts of a command (except spaces) or the rest of the command will be discarded.

The instruction mnemonics are 2-4 alphanumeric characters each. For the alphabetic characters, upper or lower case is accepted. Numeric characters which are part of the mnemonic must be as shown and are independent of numeric data.

Numeric data is allowed in a flexible format. A number may be up to 8 digits with decimal point and may be preceded by a plus or minus sign. Negative numbers are used only to program Offset, otherwise this sign is ignored. The basic number may be multiplied by a power of ten as in scientific notation. The number should then be followed by an E and the exponent (power of ten). The exponent may be up to three digits and may also be preceded by a plus or minus sign.

For certain commands, units of measurement may follow numeric data. These are optional and if omitted default as follows:

Frequency - Hertz (HZ)
Amplitude and Offset - Volts (V)

Units and their symbols are defined in the following table:

SYMBOL	DEFINITION
HZ	Hertz
KHZ	Kilohertz = 1 Thousand Hertz
MHZ	Megahertz = 1 Million Hertz
MLHZ	Millihertz = 1 Thousandth of a Hertz
V	Volts

For Frequency, HZ, KHZ, MHZ, and MLHZ, are allowed and for Amplitude and Offset, V is allowed.

Having recieved a command containing numeric data, the instrument evaluates the number including exponent and units if present. If the number is found to be within the correct range for the parameter being programmed it is accepted. If not, a GPIB Numeric Data Out of Range condition is detected which may cause a service request if unmasked and the number is discarded.

An 8 digit number is accepted in order to allow for leading or trailing zeroes but once a number is processed it is truncated past the significant digits wanted for that command.

Some examples of numeric data and their processed results are shown in the following table:

COMMAND	NUMERIC DATA	PROCESSED RESULT
FRQ	1234	1.234 KHZ
FRQ	1.234E6	1.234 MHZ
FRQ	1234E-03	1.234 HZ
AMP	5.678E-00	.567 V
AMP	.00015E4V	1.500 V
OFS	-75E-2	-.750 V
SYM	.0000002E	20

Throughout the message evaluation if an unrecognized character is found, a GPIB Syntax Error is noted which may also cause a service request if unmasked. This error does not prevent the good parts of the message from being processed, but it will indicate to the programmer that the message may not be doing its job as intended.

In addition to the individual commands, most of the instrument may be programmed in one command, PALL (Program All). The PALL command must be followed by a particularly formatted string of 25 digits called the Learn String.

INTERROGATION: TALKER FUNCTION

The instrument may be interrogated by the system controller as to the state of any of its modes or parameters. Messages are sent back to the controller. Whenever the instrument receives an interrogate command, it prepares the appropriate message to send back. Then, when it is addressed to talk it will send the message.

Note that the message is not changed until the next interrogate command is received, so if again addressed to talk, the instrument will send the same message again. On power up, a dummy message of "X" is created and kept until the first interrogation.

All interrogate command mnemonics start with the letter "I".

All messages sent are numeric and of various fixed formats. All messages are terminated by a Carriage Return (CR) and Line Feed (LF). The EOI line is asserted with the Line Feed.

The IALL command (Interrogate All) returns the 25 character Learn String, the same as used by the PALL command.

SERVICE REQUEST

A Status Byte is maintained in the instrument which is sent to the system controller whenever it asks for a Serial Poll at the instrument's address. This byte contains information on the things that may cause a Service Request and also a bit that indicates whether the instrument has actually requested service by activating the SRQ line. The Status Byte format is shown below:

STATUS BYTE

BIT NO.	BINARY WEIGHT	DESCRIPTION
1	1	Setup Error
2	2	GPIB Syntax Error
3	4	GPIB Numeric Data Out of Range
4	8	Not Used
5	16	Cal Over
6	32	Not Used
7	64	SRQ
8	128	Not Used

Bits 1-3 and 5 contain the instrument status and are at logic 1 if that condition is active. Bits 4, 6, and 8 are not used and are always zero. Bit 7 is the Service Request bit which is generated from the other bits and the SRQ Mask Byte.

The Mask Byte is used to select which of the Status Byte bits will be allowed to generate a Service Request. It may be programmed by the MSK command. It has the same format as the Status Byte except for bit 7. Bits 1-3 and 5 are used. A logic 1 in a Mask bit enables the corresponding status bit to generate a Service Request.

Whenever one of the bits of the Status Byte is set to a logic 1, if the corresponding Mask Bit is also at a 1, then the SRQ bit will be set to 1. If the Mask bit is 0, the SRQ bit is not changed.

Setting the SRQ bit to 1 also activates the hardware SRQ line to the controller. This line always reflects the condition of the SRQ bit, except that other instruments on the same bus may also pull the line.

Once set, the SRQ bit may be reset in two ways. The bit is automatically reset to 0 after the Status Byte has been read by a Serial Poll from the system controller. Also, whenever one of the Status Byte bits is reset to 0, all the bits are checked with the Mask Byte. If there are no Status Byte bits remaining at a logic 1 whose corresponding Mask bits are also at a 1, then the SRQ bit will be reset to 0 and the SRQ line will be de-activated.

Both the Status and Mask Bytes are cleared to all zeroes on power-up.

To program the Mask Byte send the MSK command with numeric data. The number should be a decimal number 0-23 which is the sum of the binary weights of the bits which are to be 1's. Thus, sending 23 sets bits 1-3 and 5 to 1, sending 6 sets bits 2 and 3 to 1 and bits 5 and 1 to 0, and sending 0 resets all bits to 0.

The Mask Byte may be queried by the IMSK command, which will return a 2 digit decimal number of the same format.

The 4 bits of the Status Byte are controlled as follows:

BIT 1 - SETUP ERROR

This bit is set to 1 whenever there are one or more setup errors and reset to 0 when all setup errors have been eliminated. The setup error may be further interrogated with the IERR command.

BIT 2 - GPIB SYNTAX ERROR

This bit is set to 1 whenever a message is received that contains a syntax error such as an unidentified character. The bit is reset to 0 when a subsequent message is received with no syntax errors.

BIT 3 - NUMERIC DATA OUT OF RANGE

This bit is set to 1 whenever numeric data following a GPIB command is found to be out of the range of allowable numbers for that command. The bit is reset to 0 when a message is received without any such errors.

BIT 5 - CAL OVER

This bit is set to 1 whenever a Cal routine is completed and reset to 0 when a Cal routine is started.

DEVICE CLEAR

The instrument accepts Device Clear (DCL) and Selected Device Clear (SDC) commands per standard GPIB protocol. Both these commands force the instrument to its power-up state.

DEVICE TRIGGER

The instrument accepts the standard Group Execute Trigger (GET) command which will trigger the generator for approximately 6 microseconds. Note that other trigger commands are also available over the GPIB as device dependent messages as well as an external trigger inhibit command.

THE LEARN STRING

The Learn String is a string of 25 digits formatted to contain setup information for most of the instrument modes and parameters. It is used with the PALL (Program All) and IALL (Interrogate All) commands.

To program all these modes and parameters in one command, send PALL followed by the Learn String. One caution to note is that limited error checking is available with this command. The instrument only checks that the string contains 25 characters which are all digits. It is possible to program an illegal mode or out of range parameter if the numbers are not correct.

The IALL command is used to interrogate the current instrument settings. Having received IALL, the instrument will send back the 25 character Learn String when subsequently addressed to talk.

The digits in the Learn String are assigned as in the following table. The interpretations of individual modes and parameters are given in the Command Summary tables in the IALL columns.

THE LEARN STRING

DIGITS	NO.	DESCRIPTION
1	1	Trigger mode
2	1	Function
3	1	Haver On/Off
4	1	Invert On/Off
5	1	Main Jack
6	1	Display Position
7-11	5	Frequency
12-16	5	Amplitude
17-21	5	Offset
22-23	2	Symmetry
24-25	2	Cal No.

COMMAND SUMMARY

This section contains detailed descriptions of all GPIB device dependent commands. It includes mnemonics for setup and interrogate commands, ranges of instrument parameters, and formats for interrogate messages.

MODES

This group of commands controls the modes of operation. For the six types of commands, the descriptions include the following:

1. Interrogate command mnemonic and number of digits in interrogate message.

2. Digit position of IALL reply in Learn String.

3. Table listing setup commands, description, interrogate command result, and IALL command result for the assigned digit in the Learn String.

TRIGGER MODE

Interrogate - IMD, 1 digit
IALL - digit 1

SETUP COMMAND	DESCRIPTION	IMD	IALL
M1	Run	1	1
M2	Gate	2	2
M3	Trigge	3	3
M4	Inhibit	4	4

FUNCTION/WAVEFORM

Interrogate - IW, 1 digit
IALL - digit 2

SETUP COMMAND	DESCRIPTION	IW	IALL
W1	Sine	1	1
W2	Triangle	2	2
W5	Square	5	5

Note: These mnemonics were chosen to be compatible with the Exact Model 628.

HAVER ON/OFF

Interrogate - IHV, 1 digit
IALL - digit 3

SETUP COMMAND	DESCRIPTION	IHV	IALL
HV0	Haver Off	0	0
HV1	Haver On	1	1

INVERT ON/OFF

Interrogate - INV, 1 digit
IALL - digit 4

SETUP COMMAND	DESCRIPTION	INV	IALL
NV0	Invert Off	0	0
NV1	Invert On	1	1

MAIN OUTPUT JACK FRONT/REAR

Interrogate - IJK, 1 digit
IALL - digit 5

SETUP COMMAND	DESCRIPTION	IJK	IALL
JK0	Both Jacks Off	0	0
JK1	Front Only On	1	1
JK2	Rear Only On	2	2
JK3	Both Jacks On	3	3

NUMERIC PARAMETERS

This group of commands controls the entry of numeric data into the five numeric parameters of the instrument. For each parameter the description includes the following:

1. Setup command mnemonics.

2. Units of measurement allowed.

3. Interrogate command mnemonic and message format of reply ("D" = digit).

4. Digit positions of IALL reply in Learn String.

5. Limits of numeric display.

6. Table listing all ranges and the full scale representations of the display, interrogate command, and IALL. The display column shows decimal point placement and units. Note that the interrogate command gives a numeric expression, with exponent, which is implied to be the most basic units (Hertz or Volts). The IALL command gives the display count, followed by a range number if applicable.

Whenever a parameter setup command is received, the instrument will move the display to that parameter, even if no numeric data is included with the command. In this way the display position may be moved without changing any numeric data. The IDSP command is used to interrogate the display position.

Setup commands followed by "n" indicate numeric data may follow the mnemonic, and by "u" indicate that units of measurement may be used.

FREQUENCY

The generator Frequency may be programmed with three different commands, FRQnu, NFRQn, and RFRQn. When the Symmetry is 50% is the only time that it makes a difference which command is used because otherwise the frequency range is chosen by the instrument itself. See Frequency.

When the Symmetry is 50% the programmer may select the physical instrument range he desires by using the RFRQ command followed by the number of the range. He may also then select the number in the Frequency display (not including decimal point) with the NFRQ command followed by the number from 1 to 1300. The table includes the range numbers for RFRQ. Note that these range numbers correspond to the powers of ten, in Hertz, of the full scale of that range as used by the IFRQ command.

The FRQnu command selects the optimum range for the Frequency programmed, using the top 10% of a range if possible.

Setup Commands - FRQnu
NFRQn
RFRQn
Units - MHZ, KHZ, HZ, MLHZ
Interrogate - IFRQ, D.DDDE+D
IALL - digits 7-11
Display limits 1 to 1300 counts

RANGE	DISPLAY	RFRQn	IFRQ	IALL
1	13.00 MHZ	7	1.300E+7	13001
2	1.300 MHZ	6	1.300E+6	13002
3	130.0 KHZ	5	1.300E+5	13003
4	13.00 KHZ	4	1.300E+4	13004
5	1.300 KHZ	3	1.300E+3	13005
6	130.0 HZ	2	1.300E+2	13006
7	13.00 HZ	1	1.300E+1	13007
8	1.300 HZ	0	1.300E+0	13008
9	130.0 MLHZ	-1	1.300E-1	13009

AMPLITUDE

Setup Command - AMPnu
Units - V
Interrogate - IAMP, D.DDDE+D
IALL - digits 12-16
Display limits 10 to 1000 counts

RANGE	DISPLAY	IAMP	IALL
1	10.00 V	1.000E+1	10001
2	1.000 V	1.000E+0	10002

OFFSET

Setup Command - OFSnu
Units - V
Interrogate - IOFS, _+_.DDDE+D
IALL - digits 17-21
Display limits -500 to +500 counts

RANGE	DISPLAY	IOFS	IALL
1	5.00 V	+.500E+1	10001
	0.00 V	+.000E+1	05001
	-5.00 V	-.500E+1	00001
2	.500 V	+.500E+0	10002
	.000 V	+.000E+0	05002
	-.500 V	-.500E+0	00002

Note: Data is shown for plus and minus limits and center (zero) of ranges. The first 4 digits of the IALL message are made by adding 500 to the display count to avoid using polarity signs and to keep the Learn String all numeric.

SYMMETRY

Setup Command - SYMn
Units - none
Interrogate - ISYM, DD
IALL - digits 22-23
Display limits 5 to 95

Only one range with units implied to be percent (%).

CAL NO.

Setup Command - CLNn
Units - none
Interrogate - ICLN, DD
IALL - digits 24-25
Display limits 1 to 68

Only one range with no units.

CAL VALUE

Setup Command - CLVn
Units - none
Interrogate - ICLV, DDDD
Display limits 0 to 4000 or depends on Cal No.

Only one range with no units.

Note: The Cal Value is not one of the primary displayed parameters. It is the number which is shown on the display during many of the Calibration steps and is adjusted either by this GPIB command or manually by the pushbuttons. Its meaning is different for each Cal No. or step. See GPIB User Cal.

DISPLAY POSITION

Setup Command - Use command for each parameter without numeric data.
Interrogate - IDSP, 1 digit
IALL - digit 6

DISPLAY PARAMETER	IDSP	IALL
Frequency	1	1
Amplitude	2	2
Offset	3	3
Symmetry	4	4
Cal No.	5	5

ENABLE BNC JACKS

These commands enable or disable certain external BNC connections. These settings are not stored in non-volatile memory, but always power up in the enabled state. Since they may not be controlled by the front panel, they all return to the enabled state whenever the Trigger Mode is changed by a front panel pushbutton.

EXTERNAL TRIGGER INPUT

Interrogate - IXTG, 1 digit

COMMAND	DESCRIPTION	IXTG
XTG0	Disables External Trigger *	0
XTG1	Enables External Trigger *	1

* Includes Manual Trigger

VCF INPUT (FM)

Interrogate - IVCF or IFM, 1 digit

COMMAND	DESCRIPTION	IVCF or IFM
VCF0 or FM0	Disables VCF (FM) Input	2
VCF1 or FM1	Enables VCF (FM) Input	1

Note: Dual mnemonics are to be compatible with the Exact Model 628 (FM).

TRIGGER

An auxiliary trigger command is supplied to set the trigger to a true or false steady state level. This feature complements the Group Execute Tigger (GET) command which is a one shot type trigger. This trigger, called the GPTR, is always reset to false on power-up and whenever the Trigger Mode is changed (by GPIB or front panel). The GPTR source must be figured in with GET and External and Manual triggers to determine when the instrument will actually be triggered.

COMMAND	DESCRIPTION
TR0	Resets GPIB Trigger False
TR1	Sets GPIB Trigger False

SETUP ERROR

Interrogate - IERR, DDD

This command interrogates the three possible groups of setup errors and replies with a string of 3 digits. Each of the 3 digits indicates the specific type of error for its group 1-3 in seqence. A 0 indicates no error for that group.

SERVICE REQUEST MASK

Setup Command - MSKn
Interrogate - IMSK, DD

These commands setup or interrogate the Service Request Mask Byte.

CALIBRATION CONTROL

The instrument may be calibrated entirely from the GPIB interface. These commands are used to control the calibration steps. They are the equivalent to pushing certain buttons which are used during front panel controlled calibration. The table lists the Command mnemonic, description, and equivalent button used for that purpose. See GPIB User Cal (2.13.4).

COMMAND	DESCRIPTION	BUTTON
CAL	Initiate Cal routine	Cal
CND	End Cal routine	Invert
ALT	Alternate Values	Display Select
NXT	Next Step	Units Down
ADV	Advance Cal no.	Units Up
STX	Store Extended	Haver

TRIGGER

The trigger capability of the instrument is used to selectively turn on cycles of the generator as desired. The instrument may be triggered from different sources. The Trigger Mode determines the generator's response to a trigger.

TRIGGER SOURCES

The generator may be triggered from four sources. To trigger the generator, any one of the enabled sources must go true. When all enabled sources go false the generator is untriggered. Note that leaving a trigger source true inadvertently may cause another source not to operate as expected.

EXTERNAL TRIGGER INPUT

This input allows for triggering by an external electrical signal. The input is DC coupled with an input impedance of 1 Kohm. The trigger goes true whenever the input signal is greater than the threshold voltage, which is fixed at approximately 1.4 volts (TTL compatible level). The external trigger may be disabled by the XTG0 command over the GPIB and re-enabled by the XTG1 command. It is also enabled on power-up and whenever the Trigger Mode is changed by front panel control.

MANUAL TRIGGER

The generator may be triggered by pushing the Manual Trigger button. This trigger source is also enabled or disabled by the XTG commands along with the External Trigger.

GPTR COMMANDS

The generator may be triggered over the GPIB with the set of commands called the GPTR. This trigger source is set true by the TR1 command and false by TR0 and remains in its programmed state. The GPTR is reset false on power-up and whenever the Trigger Mode is changed (by GPIB or front panel). This trigger source is not affected by the XTG commands.

GROUP EXECUTE TRIGGER

The generator accepts the GPIB standard command GET when addressed to listen. When the GET is received, this trigger source goes true for approximately 6 microseconds, then goes false and remains false until the next GET. This trigger is not affected by the XTG commands.

TRIGGER MODES

The Trigger Mode determines the generator's response to a trigger. When the generator is turned of it is called "locked out" and the waveform will remain at the lockout level of the waveform selected.

RUN

When in the Run Mode the generator runs continuously and is never locked out regardless of the trigger.

GATE

When in the Gate Mode the generator will run as long as it is triggered and will lock out whenever it is untriggered.

TRIGGER

When in the Trigger Mode the generator will run for one cycle only whenever it is triggered. The instrument must then be untriggered before it will generate another cycle with the next trigger.

INHIBIT

When in the Inhibit Mode the generator remains locked out regardless of triggers. This mode should be used when only a DC voltage is wanted, using Offset to set the DC level.

FREQUENCY

The generator will operate at a frequency from 0.1 millihertz to 13 megahertz. There are 9 overlapping frequency ranges. For each range the display may go from 1 to 1300 display counts, giving over two decades of variation. The ranges are listed in the table below:

FREQUENCY RANGES

RANGE	TOP OF RANGE	BOTTOM OF RANGE
1	13.00 MHz	00.01 MHz
2	1.300 MHz	0.001 MHz
3	130.0 KHz	000.1 KHz
4	13.00 KHz	00.01 KHz
5	1.300 KHz	0.001 KHz
6	130.0 Hz	000.0 Hz
7	13.00 Hz	00.01 Hz
8	1.300 Hz	0.001 Hz
9	130.0 mHz	000.1 mHz

When the Symmetry has been set to 50%, the instrument will remain internally in the range selected by the user. If the Symmetry is set to some value other than 50%, the instrument selects its own internal range as required to generate the combination of frequency and symmetry selected. The internal frequency range may be different from the displayed range.

50% SYMMETRY

When Symmetry is set to 50% the instrument stays on the range selected on the display and the frequency may be varied from 1 to 1300 counts on that range. Since ranges overlap it is possible to select some frequencies on as many as four different ranges. In general, it is best to enter the frequency in the top 10% of a range. This practice will optimize frequency accuracy and other performance factors. The FRQ command of the GPIB does this optimization. Sometimes it is necessary to use the lower region of a range, such as when sweeping using the VCF input. In this case use the NFRQ and RFRQ commands.

NOT 50% SYMMETRY

When Symmetry is set to a value other than 50% the instrument likely cannot get to the frequency it needs on the original range, so it calculates the range it needs to be on from the frequency and symmetry selected. It tries to stay on the top 10% of a range. Over GPIB it doesn't matter which commands are used, the instrument still overrides the range selection. When using the VCF input the user may not get the result he expects unless he takes the range change into consideration.

VOLTAGE CONTROLLED FREQUENCY INPUT

The generator base frequency may be varied by connecting a control voltage to the Voltage Controlled Frequency (VCF) Input.

The control voltage is summed with the generator's circuits. The frequency will vary linearly with the control voltage. A positive control voltage increases the frequency and a negative one decreases frequency from the instrument's setting. When the Symmetry is set at 50% the frequency will vary the equivalent of 400 display counts per volt of control but will not be able to exceed the limits of the frequency range selected, 1-1300 counts. When the Symmetry is other than 50%, the user will not be able to make this simple calculation because of the way the instrument controls its own frequency when varying symmetry. He should experiment to find the effect of the VCF control voltage and the limits of frequency control.

The VCF Input may be disabled by the VCF0 (or FM0) command over the GPIB and re-enabled by the VCF1 (or FM1) command. It is enabled on power-up and whenever the Trigger Mode is changed by front panel control. Also, the VCF Input is disabled when performing a frequency or symmetry calibration.

SYMMETRY

The instrument has the capability to vary the time symmetry of the output waveform over a range of 5% to 95%. Waveform symmetry is defined as follows:

% Symmetry = T[+] / Period X 100

Where: T[+] is the time of the positive sloping portion of a sine or triangle waveform or the low portion of a square waveform or Sync waveform.

Period is the time period of the entire waveform (1 / frequency).

The above definition is for non-inverted waveforms. For inverted waveforms, the above defines the waveform before it is inverted.

50% symmetry gives a normal symmetrical waveform with equal positive and negative sloping portions.

There are no restrictions on Symmetry with respect to the Trigger Mode.

When a Symmetry other than 50% is selected, the instrument calculates its own frequency control and range needed to obtain the combination of frequency and symmetry selected. The displayed frequency is the actual frequency of the asymmetrical waveform. See Frequency (2.5).

Some combinations of frequency and symmetry exceed the possible limits of the generator. No symmetry is allowed which would result in the fastest half of a waveform to be less than 38.46 nanoseconds or the slowest half of a waveform to be greater than 730 seconds. If these limits are exceeded by the frequency/symmetry combination selected an error will be indicated (Error 2). The instrument will still put out the selected frequency but will only vary the symmetry as far as is possible in these cases.

FUNCTION/SYNC

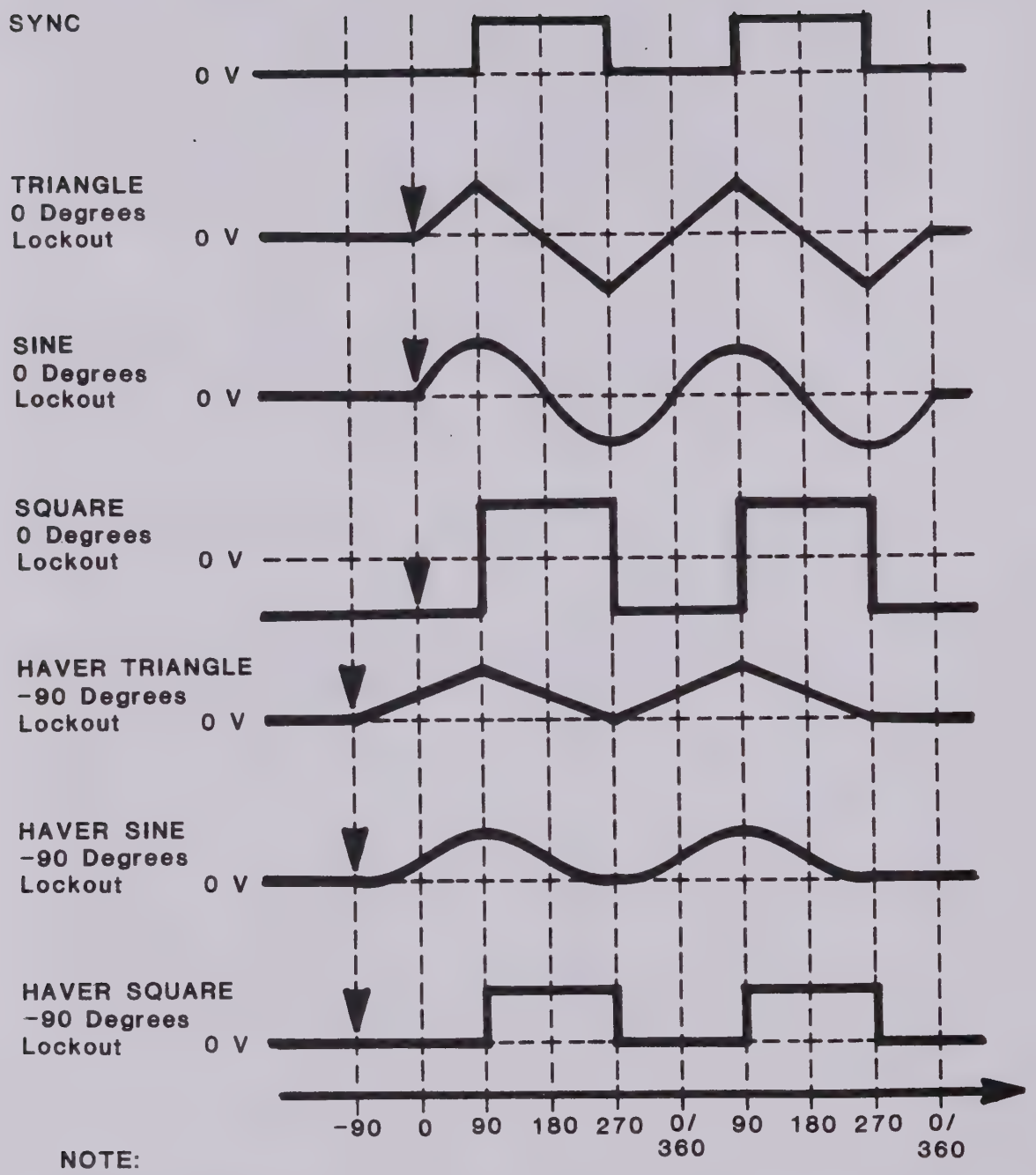
This section describes the time relationships between the three basic function generator waveforms and the Sync signal. When the function generator runs it generates internally all waveforms simultaneously regardless of which is selected at the main output. Therefore all the waveforms have a fixed relationship with each other. The triangle and sine waves are in phase together. The square wave and sync signal are in phase with each other and each switch at the same time that the sine and triangle reach their peaks.

Figure 2.2 shows the three basic waveforms in their normal and haver configurations along with the Sync signal. A triggered burst of two cycles of non-inverted waveforms is shown. Time is shown as degrees, each cycle being 360 degrees. Zero degrees is defined as the point at which the sine or triangle crosses zero volts (with no offset).

When the generator is untriggered it is held at a fixed point called the lockout level. Normal waveforms lock out at zero degrees. Haver waveforms lock out at ninety degrees before zero.

When the generator is triggered it starts running at the lockout level and always runs for an integral number of cycles before stopping again at the lockout level.

The Sync output is available on both the front and rear panels. It is at TTL levels and has a 50 ohm output impedance.



WAVEFORM/SYNC RELATIONSHIPS

FIGURE 2.2

HAVER

Waveforms may be selected to be Haver style or normal by the Haver switch or by the GPIB commands HV1 and HV0. The Haver LED indicates that the Haver style is selected. Haver waveforms lock out at ninety degrees before zero of the waveform cycle.

Haver waveforms' most negative peaks are at zero volts (with no offset selected) which is their lockout level. Non- inverted haver waveforms swing from zero volts to a positive peak voltage selected by the Amplitude parameter so that their zero to peak voltage is the same as their peak to peak voltage.

Non-haver waveforms are centered around ground and swing equally in plus and minus voltages (with no offset).

Both haver and normal waveforms may use the full range of the output amplifier so that the entire waveform including amplitude and offset settings is allowed to swing from minus 10 volts to plus 10 volts. However, a haver waveform must be offset in the opposite direction of its peak voltage to obtain an amplitude greater than 5 volts.

When the instrument is switched from normal to haver waveforms, the amplitude is divided in half, including the number in the Amplitude parameter display. This is done to prevent clipping of the amplifier. Likewise when switching from haver back to normal, the amplitude is doubled. In this way, when switching between haver and normal waveforms, the positive peak of the waveform always stays in the same place. If halving or doubling the amplitude would exceed the low or high limits of the amplitude parameter, an underflow (uF) or overflow (oF) indication is shown on the Amplitude display and an error will be indicated (Errors 1-4 and 1-3). Pressing the Haver button again will restore the previous Amplitude and Haver mode or pushing one of the numeric data entry switches will set the Amplitude to either a legal minimum or maximum value.

INVERT

Waveforms may be inverted and re-righted by the Invert switch or by the GPIB commands NV1 and NV0. The Invert LED when on indicates that the waveform is inverted. Inverted waveforms may be recognized because thay start off in a negative direction when triggered. Inverted haver waveforms lock out at the positive peak which is at zero volts and swing to a negative peak. Inverted square waves are the opposite polarity as the Sync signal.

The Invert switch inverts everything about the waveform except for the DC Offset.

MAIN OUTPUTS

The instrument has both front and rear main outputs. They may be turned on or off in any combination either by performing a Cal 5 or over the GPIB with the JK0, JK1, JK2, and JK3 commands. The table shows the Cal 5 number to be entered and the GPIB command to use for the combination desired.

MAIN JACKS	CAL 5 NO.	GPIB COMMAND
Both Off	0	JK0
Front Only On	1	JK1
Rear Only On	2	JK2
Both On	3	JK3

The instrument is shipped from the factory with the front jack enabled. If changed by the user the main jack configuration will be stored in non-volatile memory until re-configured.

To perform a Cal 5 first this cal number must be enabled by the Cal Control Code, set up by Cal 10). Then set the Cal No. to 5 and press the Cal button. The current main jack configuration number will be displayed (with all display select LED's off). Enter the new configuration number with the numerical data entry switches. Push the Invert button to store the new number. The display will return to its previous state and the main jacks will be set to their new configuration. The same procedure is used when only needing to view the current main jack configuration. Pushing Invert is the only way to exit the Cal 5 routine. The Cal 5 routine may not be entered remotely over the GPIB.

The instrument output amplifier is shared by the two output jacks. The output source impedance is 50 ohms. To obtain the best waveform quality, especially at high frequencies, only one output should be used at a time and it should be terminated at its destination with a 50 ohm load to ground. Instrument specifications for waveform quality and for Amplitude and Offset are for this configuration. When the output is connected to a high impedance the Amplitude and Offset voltages are double the displayed values.

If both output jacks are used at the same time make sure that both are not loaded with 50 ohm loads. 50 ohms is the smallest total resistance that should be put on the outputs.

The output amplifier is protected from the application of excessive voltage by a clamp circuit and also by a fuse for each output jack. If either output jack does not appear to be operating check the fuse. See Fuses

AMPLITUDE/OFFSET

The main output peak to peak Amplitude may be varied from 10 millivolts to 10 volts. Non-haver waveforms are centered around zero volts. Non-inverted haver waveforms swing from zero volts to a positive peak voltage. Inverted haver waveforms swing from zero volts to a negative peak. See Haver.

A DC Offset may be added to the basic waveform from minus 5 volts to plus 5 volts. When a non zero number is entered into the Offset parameter, the Offset On LED comes on.

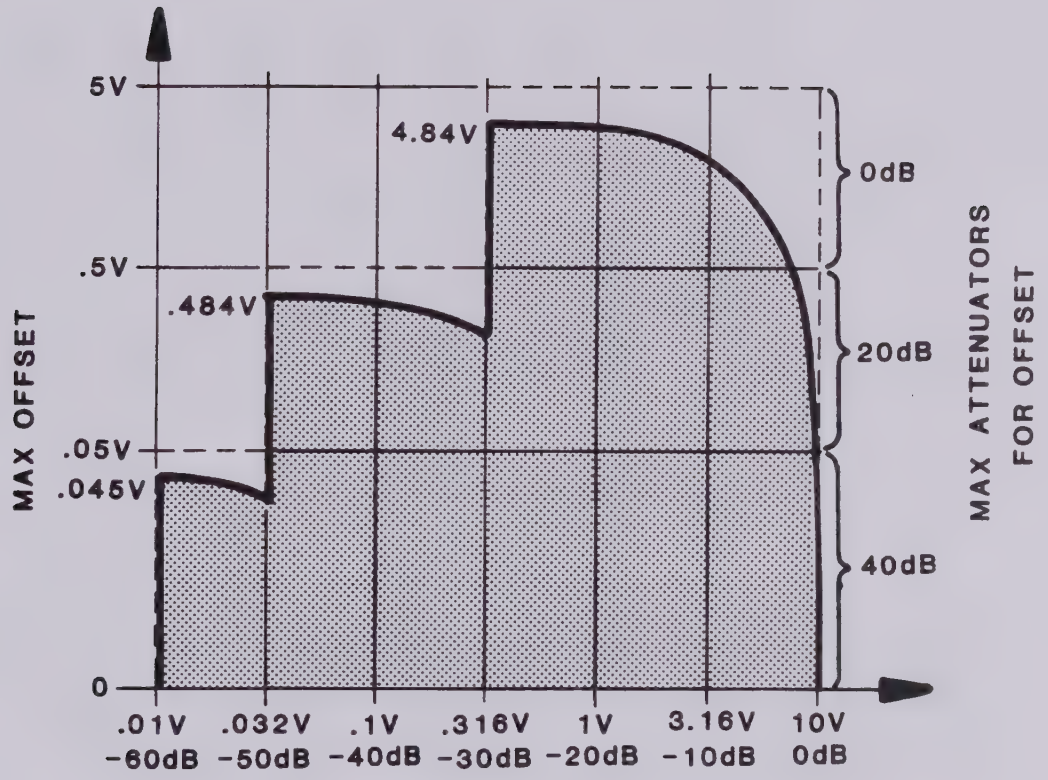
For both Amplitude and Offset, the displayed amount is the correct value when the main output is terminated with a 50 ohm load to ground. When the main output is unloaded, its Amplitude and Offset voltages are actually twice the displayed amount.

There are two display ranges each for both Amplitude and Offset, listed with the GPIB Command Summary . Note that these display ranges are converted by the instrument to its own internal attenuator ranges and therefore it makes no difference what display range is used to enter an Amplitude or Offset value as long as the display range has the resolution desired.

When Offset is added to the basic waveform it is possible to exceed the instrument's capabilities in two different ways, causing setup error indications. First, the addition of Amplitude and Offset voltages may result in a waveform which exceeds the voltage limits of the output Power Amplifier (PA) (Error 1-1). Second, for a given amount of Offset, the Amplitude may be too small (Error 1-2). Figure 2.3 shows the approximate limits of combinations of Amplitude and Offset which are obtainable. Note that haver waveforms have different positive and negative limits since they are not symmetrical to start with.

The exception is in Inhibit Mode where the sum of the lockout level and the Offset may be 5 Volts in either polarity.

The graph indicates the maximum Offset allowable for a given amount of Amplitude:



VALID LIMITS FOR AMPLITUDE/OFFSET COMBINATIONS

FIGURE 2.3

1. Non-haver waveforms may have positive or negative Offset to the solid line.

2. Non-inverted haver waveforms may have positive Offset to the solid line or negative Offset to the dashed line.

3. Inverted haver waveforms may have positive Offset to the dashed line or negative Offset to the solid line.

The maximum Offset boundary is stepped because of the scheme used by the instrument to obtain the full range of amplitudes. The signal first goes through an amplitude control circuit which attenuates it up to 20 dB, then through the power amplifier (PA). Then it may be further attenuated by one or both of the 20 dB attenuators. In this way, the signal amplitude is controlled from 10 volts full scale (0 dB) to 10 millivolts (-60 dB). DC offset is added to the signal before the PA.

Note: Every 10 dB of attenuation divides the full scale amplitude by the square root of 10.

For every selected combination of Amplitude and Offset, the instrument computes the configuration of attenuators and amplitude and offset controls. The amplitude attenuator range is determined as in the table and attenuators are selected to get in that range. The amplitude control is calculated to get the right amplitude within that range.

AMPLITUDE ATTENUATOR RANGES

ATTEN RANGE (-dB)	AMPLITUDES
0	1.001 V to 10.00 V
20	.101 V to 1.000 V
40	.010 V to 0.100 V

When Offset is used, there is a maximum to the number of attenuators which may be used or the offset may not be obtainable. The following table shows the maximum attenuators possible for different amounts of offset. If necessary and if possible, the instrument will use more attenuation in the amplitude control circuit, up to 30 dB, in lieu of an attenuator.

OFFSET MAXIMUM ATTENUATOR RANGES

ATTEN RANGE (-dB)	OFFSETS
0	.501 V to 5.00 V
20	.051 V to .500 V
40	0 V to .050 V

If the amplitude is too small for the required offset attenuator range, then an error will be indicated (Error 1-2). If this happens, the offset will prevail and will be output correctly while the amplitude will be the minimum possible. This error occurs in Figure 2.3 when the boundary is exceeded horizontally to the left.

Another error is caused when the waveform created by the addition of amplitude and offset voltages exceeds the voltage limits of the power amplifier (PA) (Error 1-1). This error occurs in Figure 2.3 when the boundary is exceeded vertically. When this error occurs the offset will prevail and will be output correctly while the amplitude will be the maximum possible.

AMPLITUDE MODULATION (Optional)

An optional rear BNC jack may be added for an Amplitude Modulation input. A control voltage may be connected to vary the amplitude of the waveform. The amplitude varies proportionatly to the control voltage. A positive voltage increased the amplitude and a negative voltage decreases the amplitude.

The upper limit of amplitude when modulated is the upper limit of the attenuator range, which is determined from the numeric Amplitude setting, see table. When using AM, pick a base Amplitude in a range which includes the maximum amplitude desired when modulated. The AM input impedance is 600 ohms.

MEMORY

The instrument has a non-volatile memory (battery backed RAM) which retains its contents even when power is turned off. This memory is used to store instrument settings, calibration values, the GPIB address, and the Cal Control Code.

When the instrument is powered up it remembers its last settings and returns to those conditions.

A provision is made for initializing the instrument if a raw unprogrammed RAM is installed or if it is accidentally loaded with "garbage". If switch 1 of the internal DIP switch on the top PC board is ON, the instrument will power up into a known good state. If switch 2 is ON, all the calibration constants will be initialized. Note that if both switch 1 and 2 are both on the instrument will enter a diagnostic routine. See DIP Switch.

USER CALIBRATION

The Model 627 has several calibration routines built in to its own operating program. It has the capability to measure its own frequency and symmetry and adjust those parameters for optimum accuracy. It also has routines which interact with the operator which facilitate the calibration of other parameters. In fact, there are no internal adjustments inside the instrument. All calibration may be accomplished without removing the instrument covers. There are 4 rear panel test points which are used.

The calibration routines are divided into 3 groups, User Cal, Factory Cal, and Auxiliary Cal. The User Cal routines are described in this section. The Factory Cal routines are for doing a complete instrument calibration and are described in Section 3. The Auxiliary Cal routines are troubleshooting aids and are described in Section 4. The Cal Numbers for the different groups are as follows:

User Cal	1-10
Factory Cal	11-44
Auxiliary Cal	45-68

Cal routines may be enabled or disabled as desired to protect the calibration constants by setting the Cal Control Code using the Cal 10 routine. This Code number enables different Cals for different conditions. Before attempting to initiate a Cal, it must have been enabled by the Code. If pushing the Cal button does nothing, probably that Cal routine is disabled.

To initiate a Cal routine enter the number of the Cal routine into the Cal No. and push the Cal button.

Some of the User Cals are completely automatic and are designated AUTO in their description. Others require the operator to do a series of steps and are designated MANUAL.

Note that some of the User Cals are not really instrument calibrations but just convenient ways to set up or display certain parameters of operation.

SERVICE REQUEST

Bit 5 of the GPIB Status Byte is used to indicate when a calibration routine is over. This bit is set to a 1 whenever a Cal routine ends. It is reset to 0 when another Cal routine starts. If unmasked by the Masked Byte, the bit will generate a GPIB Service Request.

USER CAL ROUTINES

The User Cal routines are described here by number. Also refer to the notes following.

CAL 1: OFF (Auto)
Ends the Cal 2 routine which runs continuously.

CAL 2: CONTINUOUS FREQUENCY CAL (Auto)
Continuously adjusts the frequency for best accuracy. Operates only in Run mode. Inhibits the VCF input. This routine stays on until ended by Cal 1.

CAL 3: FREQUENCY ON DEMAND (Auto)
Adjusts the frequency one time only. Operates in any trigger mode.

CAL 4: FREQUENCY RANGE (Auto)
Adjusts the current frequency range for best fit accuracy over the whole range. Also adjusts the waveform symmetry.

CAL 5: MAIN OUTPUT JACK (Manual)
Turns on or off the front and rear Main Output jacks. See Main Outputs.

CAL 6: SUPER CAL (Auto)
Calibrates all frequency ranges and symmetry. Stores all generated constants permanently in non-volatile memory.

CAL 7: ERASE (Auto)
Erases all calibration constants generated by Cals 2-4 since the last instrument power-up or Super Cal (Cal 6). Returns to constants stored in non-volatile memory.

CAL 8: SOFTWARE REVISION NUMBER (Manual)
Displays the revision number of the instrument's own internal software program. Push the Invert button to exit the Cal 8 routine.

CAL 9: GPIB ADDRESS (Manual)
Enters the GPIB adress into non-volatile memory. See GPIB Address.

CAL 10: CAL CONTROL CODE (Manual)
Enters the Cal Control Code into non-volatile memory. See Cal Control Code.

NOTES:

1. Calibration constants generated by Cals 2 and 3 are used at the current frequency only and for as long as the instrument stays at that frequency and function. When the frequency or function (waveform) is changed the instrument reverts to the constants previously used for that frequency range with that function. The range constants use the best fit method for all frequencies over that range. Cal 2 or 3 must be used to improve on an individual frequency accuracy within a range. If the frequency or function is changed while Cal 2 is on, the intrument will first revert to the range constants and then continue with the Cal 2 routine. See Note 5.

2. Cals 2 and 3 only operate at frequencies of 1 Hz and above. If a Cal 2 or 3 is attempted at a lower frequency or with an incorrect mode an error is indicated (Setup Error 3).

3. When a Cal routine is active the Cal LED lights. Except for Cal 2, the instrument will not accept any input from front panel switches or GPIB commands at this time except those switches or commands which are specifically used with that Cal routine.

4. Calibration constants generated by a Cal 6 Super Cal are stored permanently in non-volatile memory. When the instrument is powered up, these constants are used. Constants generated by Cal 4 are kept active as long as power remains on but are lost when power is turned off. Since Super Cal constants are permanently stored, it is recommended that the instrument be warmed up for one hour before performing a Cal 6.

5. Because of the instrument's internal characteristics different calibration constants are used for different functions (waveforms) when calibrating frequency. The Sine, Triangle, and Square waveforms are calibrated separately. Also the 9 frequency ranges are calibrated separately for a total of 27 combinations. Cal 4 only calibrates the combination currently selected. Cal 6 calibrates all combinations.

6. Cals 5 and 9 may not be performed from the GPIB.

CAL CONTROL CODE

The Cal Control Code is used to prevent certain Cal routines from being performed under certain conditions. This feature allows for the protection of calibration constants from accidental changes.

The Code number may be from 0 to 6 and is entered into non-volatile memory with the Cal 10 routine.

The Code numbers are defined as follows:

CODE 0: Cals 1-5 and 10 enabled.

CODE 1: Cals 1-5 and 10 enabled only when the Cal number is actively displayed.

CODE 2: Cals 1-10 enabled.

CODE 3: Cals 1-10 enabled only when the Cal number is actively displayed.

CODE 4: All Cals enabled only when the Cal number is actively displayed. With this code, the Cal Value being changed is displayed when doing a manual factory cal.

CODE 5: All Cals enabled only when the Cal number is actively displayed. With this code, the Cal number itself remains displayed when doing a manual factory cal.

CODE 6: Cal 10 only enabled only when the Cal number is actively displayed.

The Cal Control Code only inhibits Cals started from the front panel and does not have any control over Cals started by the GPIB CAL command.

To enter the Cal Control Code set the Cal Number to 10 and push the Cal switch. The display will now show the current code number. Enter the new code with the numerical data entry switches. Push the Invert button to store the new code. The display will return to its previous state. The same procedure is used when only needing to read the code. Pushing Invert is the only way to exit the Cal 10 routine.

The instrument is shipped from the factory with the Cal Control Code set to 3.

GPIB USER CAL

The instrument may be calibrated completely from the GPIB interface. In the case of User Cal, only 2 GPIB commands are needed. Instead of pushing a button, when so directed by the Cal routine, send the GPIB command. The CAL command is sent instead of pushing the Cal button to initiate a Cal routine. The CND command is sent instead of pushing the Invert button to end a Cal routine. See Calibration Control.

SETUP ERRORS

In some modes of operation, certain parameters may conflict with others to create an illegal combination. This may occur even though each individual parameter is within its own specified limits. The instrument allows entry of numeric data within a parameter's limits at any time regardless of any other paramter's current setting. In this way the operator is not required to enter parameters in any particular order. When an illegal combination is entered it is called a Setup Error. When a Setup Error is present, various LED's will flash on the front panel to indicate the type of error.

SERVICE REQUEST

Bit 1 of the GPIB Status Byte is set to 1 whenever one or more Setup Errors are present. It is reset to 0 when all errors have been eliminated. If unmasked by the Mask Byte, the bit will generate a GPIB Service Request.

INTERROGATE ERROR

The state of all possible Setup Errors may be interrogated over the GPIB by the IERR command. The instrument will return a string of 3 digits. The digits represent the states of the 3 categories of errors, in order, 1 through 3. Their meaning is listed in the Error Summary.

ERROR SUMMARY

The conditions that can cause errors are defined here in 3 categories. The number of the detailed description within each category is the number returned in the IERR string for that digit. When GPIB is not used, the flashing LED's will give clues as to the category and type of error.

ERROR 1: AMPLITUDE/OFFSET

Amplitude and Offset are incompatible with each other, not applicable in Inhibit mode.

0 = No error.
1 = Amplitude added to Offset exceeds limits of Power Amplifier (PA).
2 = Amplitude too small for Offset.
3 = Amplitude overflows display limit (10.00 V).
4 = Amplitude underflows display limit (0.010 V).

ERROR 2: FREQUENCY/SYMMETRY

Frequency and Symmetry are incompatible with each other, not applicable in Inhibit mode.

0 = No error.
1 = Frequency too high for Symmetry.
2 = Frequency too low for Symmetry.

ERROR 3: CAL

Impossible Cal attempted.
0 = No error.
1 = Cal 2 attempted, frequency less than 1 Hz or not in run mode.
2 = Cal 3 attempted, frequency less than 1 Hz.

DIP SWITCH

Internal to the instrument at the rear of the top PC board there is a miniature DIP (Dual In-line Package) switch which contains four separate switches. They are all shipped from the factory in the off position. The top cover if the instrument must be removed to switch them. When the switches are on, the instrument's operation is changed as described below.

An additional included feature is a power-up self test which is entered if the instrument is powered up with both switches 1 and 2 on. See Power-up Self Test.

SWITCH 1: On power-up, the instrument will enter a known good state instead of recalling the state when last powered.

SWITCH 2: On power-up, the instrument will initialize the calibration constants to a raw condition. This should not be done unless prepared to perform a Factory Calibration.

SWITCH 3: Presents all Cal routines greater than 10 from being performed (Factory Cal).

SWITCH 4: Keeps the outputs from being turned off during User Cal so the Cal routines may be observed.

SUMMARY SHEET

Figure 2.4 is a single sheet which lists the GPIB setup commands for the Model 627. It also contains short descriptions of the Status Byte, Setup Errors, User Cal routines, Control Codes, IEEE-3488 Subsets, and of the DIP switch. This sheet is meant to be a quick reference guide.

MODEL 627 SUMMARY SHEET

TRIGGER MODE
- M1 Run
- M2 Gate
- M3 Trigger
- M4 Inhibit

FUNCTION/WAVEFORM
- W1 Sine
- W2 Triangle
- W5 Square

HAVER ON/OFF
- HV0 Haver Off
- HV1 Haver On

INVERT ON/OFF
- NV0 Invert Off
- NV1 Invert On

MAIN OUTPUT JACK
- JK0 Both Off
- JK1 Front only
- JK2 Rear Only
- JK3 Both On

NUMERIC PARAMETERS
- FRQnu Frequency MHZ,KHZ,HZ,MLHZ
- NFRQn Frequency Number
- RFRQn Frequency Range
- AMPnu Amplitude Range
- OFSnu Offset V
- SYMn Symmetry
- CLNn Cal No.
- CLV Cal Value

SERVICE REQUEST
- MSKn Mask Byte

STATUS BYTE BITS/WEIGHT

1	Setup Error	1
2	GPIB Syntax error	2
3	GPIB Numeric Data	4
4	Not Used	8
5	Cal Over	16
6	Not Used	32
7	SRQ	64
8	Not Used	128

EXTERNAL TRIGGER
- XTG0 Disable
- XTG1 Enable

VCF (FM) ENPUT
- VCF0 Disable
- VCF1 Enable
- FM0 Disable
- FM1 Enable

GPTR TRIGGER
- TR0 Resets to 0
- TR1 Sets to 1

IEEE-488 SUBSETS
SH1,AH1,T6,TE0, L4,LE0,SR1,RL1, PP0,DC1,DT1,C0, E2

USER CAL ROUTINES
1. Turns off Cal 2
2. Continious Frequency
3. Frequency On Demand
4. Frequency Range
5. Main Output Jack
6. Super Cal
7. Erase
8. Software Rev No.
9. GPIB Address
10. Cal Control Code

SETUP ERRORS/IERR/BUTTON
1. Amplitude/Offset
2. Frequency/symmetry
3. User Cal

DIP SWITCH
1. Initializes Inst. Settings
2. Initializes Cal Constants
3. Disables Factory Cal
4. Enables Main Out Usr Cal

CAL CONTROL CODE
- 0: 1-5,10
- 1: 1-5,10,if cal no. displayed
- 2: 1-10
- 3: 1-10,if cal no. displayed
- 4: All,if Cal No. displayed Cal Value shown during Cal
- 5: All, if Cal No. displayed Cal No. shown during Cal
- 6: 10 only, if Cal No. displayed

CAL CONTROL/DESCR/BUTTON

CAL	Start Cal	Cal
CND	End Cal	Invert
ALT	Alternate	Display Select
NXT	Next Step	Units Up
ADV	Advance No.	Units Down
STX	Store Extend	Haver

FIGURE 2.4

SECTION 3

CALIBRATION PROCEDURE

INTRODUCTION

The calibration procedure in this section refers to FACTORY CAL and should not be confused wish USER CAL routines. FACTORY CAL routines are selected by Enabling cals 11 and up using the CAL CONTROL CODE and setting DIP switch 3 on the CONTROLLER PCB off. This switch may be left off allowing factory cal to be entered from the front panel alone, or with it on and the top cover installed the unit is protected from unathorized calibration.

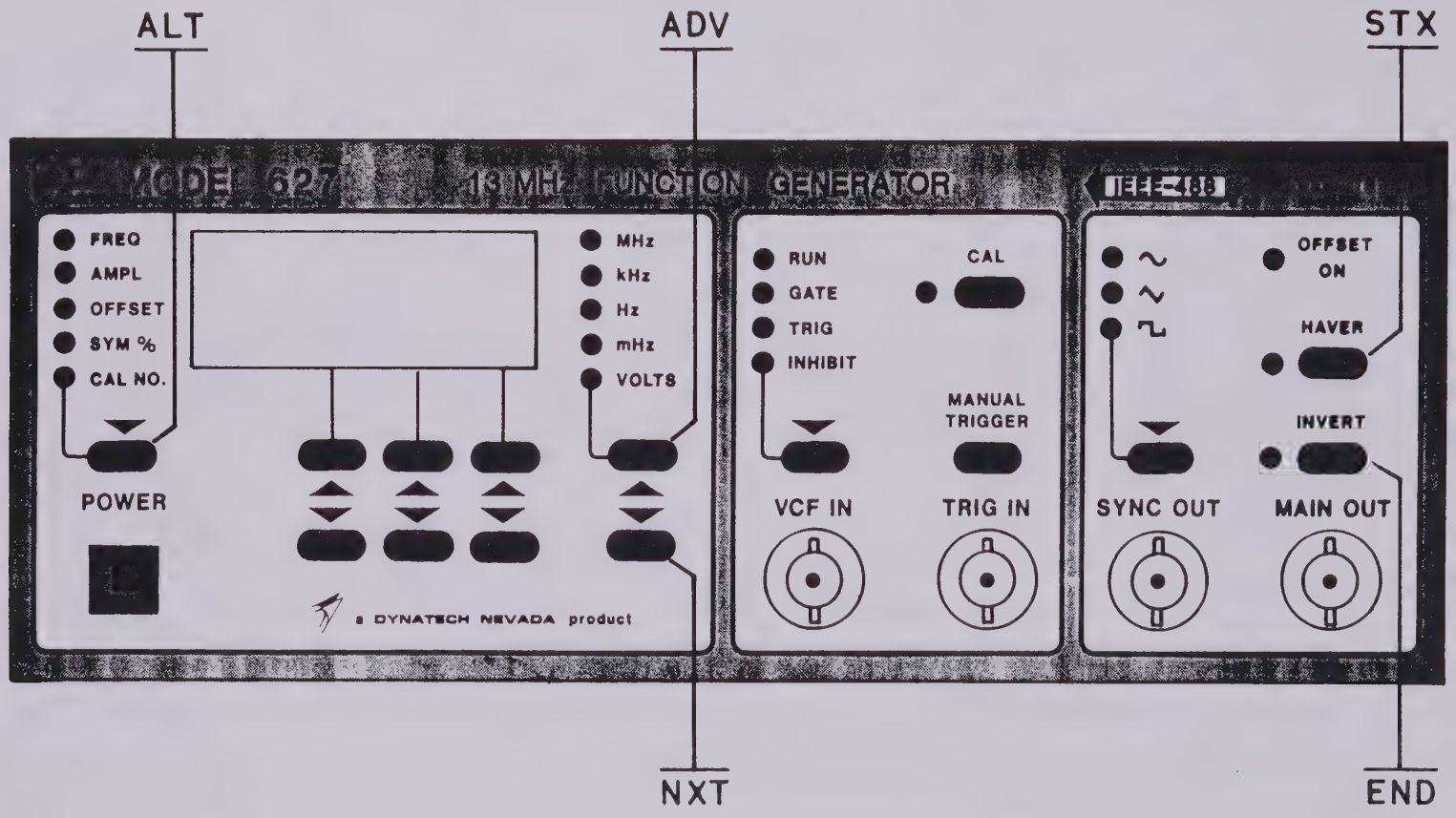
A complete procedure is included for initializing and calibrating a new instrument as it would be at the factory. In this case, the INITIAL SETUP, the CALIBRATION, and FINAL SETUP should be performed.

In practice in the field, the INITIAL SETUP is only required to be performed if the ZRAM (U26 on the CONTROLLER PCB) is replaced or erased. Powering up an instrument with DIP switch 2 on results in initializing most cal constants to a raw state. Afterwards a complete calibration is required.

All calibration is done from the front panel, there are no internal adjustments. The functions of the front panel switches are redefined for this procedure as shown in figure 3.1. Some of the cals are performed automatically requiring only starting the cal by depressing CAL with the apropriate CAL NO. displayed or by depressing ADVance if the previous CAL NO. is displayed and the previous cal is completed. If the previous cal was an automatic cal, the CAL light will flash when the cal is done. During an automatic cal, the CAL light is lit. The CAL light is lit during and after non-automatic cals. The non-automatic cals require setting a particular parameter with the NUMERIC DATA ENTRY SWITCHES, then entering the value by depressing END to end the cal or by depressing ADVance to go to the next cal. Some cals require setting 2 parameters before ending the cal. After the first parameter is set, depressing ALTernate will advance to the other parameter. It is nessessary to ALTernate between the 2 parameters several times because they may interact. Some cals require 4 adjustments, after the first two are done, depressing NXT(NeXT) will advance to the next two, ADV and END will do nothing until NXT has been depressed. The calibration procedure steps through each of these situations as required.

The STX button (STore eXtended) provides a means of doing a quicker rouph calibration by allowing some steps to be skipped. After doing cal step 21, depress STX , then skip the steps marked with a asterisk(*).

It is not nessessary to do all the steps. Any step may be done by setting the appropriate CAL NO., depressing CAL, and at the end of the step, depressing END.



FACTORY CAL KEY ASSIGNMENTS

FIGURE 3.1

EQUIPMENT REQUIRED

The following equipment is required to perform a complete calibration:

OSCILLOSCOPE: DC to 100 Mhz with differential comparator.

DIGITAL VOLTMETER (DVM): 4 1/2 digits

DISTORTION ANALYZER: .1% residual distortion

INITIAL SET UP

LINE VOLTAGE

Set the appropriate line voltage by pulling out the card behind the fuse and reinserting it with the proper voltage visible. Install a fuse of value stated on the rear panel.

INITIAL CONDITIONS

This step should be done only if the ZRAM has been replaced or erased. Set DIP switchs 1 and 2 on, set DIP switchs 3 and 4 off. Turn the power on. If it is already on, turn it off then on. Wait about 10 seconds for the front panel to come up with the initial conditions stated in the OPERATING INSTRUCTIONS. Set DIP switchs 1 and 2 off.

CALIBRATION PROCEDURE

WARM UP

Allow 1 hour warm up with covers in place prior to calibrating.

ENABLE FACTORY CAL

Set DIP switch 3 off. Set PARAMETER DISPLAY to CAL. Set NUMERIC DISPLAY to 10. Depress CAL. Set NUMERIC DISPLAY to 4 if it is desired to display the cal value during calibration or, set the NUMERIC DISPLAY to 5 if it is desired to display the cal number during calibration. Depress END.

NOTE: The following procedure was written assuming that each step will be performed in order. So each step starts with 'Depress ADV'. This only works if the CAL NO. reads the number of the previous step and the CAL light is on or flashing.

+5 VOLTS (CAL 11)

Set NUMERIC DISPLAY to 11. Depress CAL. The numeric display now reads the cal number (11) or a number proportional to the cal value (approx. 2000) depending on the mode set in the previous step. Connect the voltmeter, using tip plugs, to TP 4 (ground) and TP 3 (+5V). Adjust the NUMERIC DATA ENTRY SWITCHS for a DVM reading of 5V +/-.01V.

+15 VOLTS (CAL 12)

Depress ADV. (The display should read 12 for an instant then switch to the cal value or stay at 12 depending on the mode set above. If it does not, depress END to get out of cal, set the display to 12 and depress CAL). Connect the DVM from TP 4 (ground) and TP 2 (+15V). Adjust the NUMERIC DATA ENTRY SWITCHES for a DVM reading of +15V +/-.01V.

-15 VOLTS (CAL 13)

Depress ADV. Connect the DVM to TP 4 (ground) and TP 3 (-15V). Adjust the NUMERIC DATA ENTRY SWITCHES for a DVM reading of -15V +/-.01V. Remove DVM leads.

SYMMETRY (CAL 14)

Depress ADV. This is an automatic cal. It may be watched on the MAIN OUTPUT. When it is done the CAL light will flash. It takes about 20 seconds but can vary considerably.

NOTE: Once any of the automatic cals are started, they can only be terminated by turning the power off and on.

LOW RANGES SYMMETRY (CAL 15)

Depress ADV. This is an automatic cal. It takes about 20 seconds.

FREQUENCY RANGES (CAL 16)

Depress ADV. This is an automatic cal. It takes about 3 minutes.

VARIABLE SYMMETRY BALANCE (CAL 17)

Depress ADV. This is an automatic cal. It takes about 1 minute.

SINE DISTORTION (CAL 18)

Depress ADV. Connect MAIN OUTPUT to Distortion Analyzer set to 1.3Khz. Adjust the NUMERIC DATA ENTRY SWITCHES for minimum distortion. Depress ALTernate and adjust for minimum distortion. Continue alternating until no more improvement can be obtaimed, typically .2%.

SINE AMPLITUDE (CAL 19)

Depress ADV. Connect MAIN OUTPUT,terminated into 50 ohms,to oscilloscope. The terminator should be 50 ohms +/- .25 ohms. The output waveform is a sinewave of approximately 10V p-p. The PARAMETER DISPLAY reads OFFSET meaning that the NUMERIC DATA ENTRY SWITCHES will adjust the offset of the waveform. Depress ALT and the PARAMETER DISPLAY reads AMPLitude meaning that the amplitude of the waveform can be adjusted.. Alternate between these 2 adjustments until the waveform peaks are at +5V +/-.005V and -5V +/-.005V.

Depress NXT. The output waveform is now approximately 1Vp-p. Using ALT and the NUMERIC DATA ENTRY SWITCHES adjust the waveform for peaks of +.5V +/-.001V and -.5V +/-.001V as above.

TRIANGLE AMPLITUDE (CAL 20)

Depress ADV. The output waveform is a triange. Follow the procedure used to adjust the sinewave to adjust this waveform.

SQUARE AMPLITUDE (CAL 21)

Depress ADV. Repeat the above procedure for the squarewave.

STX may be depresed now to do a rouph calibration as described in the introduction. The steps that may be skipped are marked with an asterik (*).

INVERTED SINE AMPLITUDE (CAL 22) *

Depress ADV. Repeat as for the sinewave above.

INVERTED TRIANGE AMPLITUDE (CAL 23) *

Depress ADV. Repeat above procedure.

INVERTED SQUARE AMPLITUDE (CAL 24) *

Depress ADV. Repeat above procedure.

SINE LOCKOUT LEVEL (CAL 25)

Depress ADV. The output waveform is a locked out sinewave, apprximately 0V DC. Use the NUMERIC DATA ENTRY SWITCHES to adjust for 0V +/-.01V.

TRIANGLE LOCKOUT LEVEL (CAL 26)

Depress ADV. Repeat the previous step for the triangle.

INVERTED SINE LOCKOUT LEVEL (CAL 27)

Depress ADV. Repeat the above step for the sinewave.

INVERTED TRIANGE LOCKOUT LEVEL (CAL 28)

Depress ADV. Repeat the above step for the triangle.

OFFSET GAIN (CAL 29) *

Depress ADV. The output is about +5V. Adjust for +5V+/-.005V.

HAVERSINE DC (CAL 30) *

Depress ADV. The output is a 0V to +5V sinewave. Adjust the negative peak for 0V +/-.005V.

HAVERTRIANGLE DC (CAL 31) *

Depress ADV. Repeat the previous step for the triangle.

HAVERSQUARE DC (CAL 32) *

Depress ADV. Repeat the previous step for the square.

INVERTED HAVERSINE DC (CAL 33) *

Depress ADV. Repeat the previous step for the inverted sine.

INVERTED HAVERTRIANGE DC (CAL 34) *

Depress ADV. Repeat the previous step for the inverted triange.

INVERTED HAVERSQUARE DC (CAL 35) *

Depress ADV. Repeat the previous step for the inverted square.

HAVERTRIANGE MINUS PEAK LOCKOUT LEVEL (CAL 36)

Depress ADV. Adjust the output for 0V +/-.005V.

HAVERTRIANGLE PLUS PEAK LOCKOUT LEVEL (CAL 37)

Depress ADV. Adjust the output for 0V +/-.005V.

INVERTED HAVERTRIANGLE MINUS PEAK LOCKOUT (CAL 38)

Depress ADV. Adjust the output for 0V +/-.005V.

INVERTED HAVERTRIANGLE PLUS PEAK LOCKOUT (CAL 39)

Depress ADV. Adjust the output for 0V +/-.005V.

20 DB ATTENUATOR GAIN (CAL 40) *

Depress ADV. The output is a 1Khz, 1V p-p squarewave. Adjust it for 1V +/-.001V.

40 DB ATTENUATOR GAIN (CAL 41) *

Depress ADV. The output is a 1Khz, .1V p-p squarewave. Adjust it for .1V +/-.001V.

SINE BANDWIDTH (CAL 42)

Depress ADV. The output is a full amplitude, maximum frequency sinewave. Connect it to the oscilloscope using a 50 ohm coaxial cable terminated into 50 ohms. Adjust it for 10V p-p +/- 2dB(2.05V). Depress NXT. The output is a 2V p-p sinewave. Adjust it for 1/10 the amplitude set above. If the second adjustment is out of range, readjust the maximum amplitude to bring it in range by depressing END then CAL to repeat the step.

TRIANGE BANDWIDTH (CAL 43)

Depress ADV. The output is a full amplitude, maximum frequency triangle. Connect it to oscilloscope terminated in 50 ohms. Adjust it for as high an amplitude as possible (<10V p-p) while maintaining a high quality waveform. Depress NXT. Adjust for 1/10 the amplidude set above. Repeat if out of range as in the previous step.

SQUARE RISE TIME AND ABBERATIONS (CAL 44)

Depress ADV. The output is a full amplitude, 1 MHz squarewave. Connect it to oscilloscope terminated in 50 ohms. Adjust it for a rise and fall times of <20nsec, and for aberations of <5%(.5V). Depress NXT. The output is a 2V p-p squarewave. Adjust it to be the same as the full amplitude waveform. Depress END.

FINAL SETUP

This completes the calibration procedure. Disable FACTORY CAL by setting the CAL NO. to 10, depressing CAL, setting the cal control code as desired (see OPERATING INSTRUCTIONS) but not 4 or 5, then depressing END. If DIP switch 3 on the controller PCB is set on, the calibration is protected once the top cover is in place.

CALIBRATION STEP CHART

Below is a chart listing the calibration steps by CAL NO.

CAL NO.		NAME
11		+5 VOLTS
12		+15 VOLTS
13		-15 VOLTS
14		SYMMETRY
15		LOW RANGES SYMMETRY
16		FREQUENCY RANGES
17		VARIABLE SYMMETRY BALANCE
18		SINE DISTORTION
19		SINE AMPLITUDE
20		TRIANGLE AMPLITUDE
21		SQUARE AMPLITUDE (STX: *)
22	*	INVERTED SINE AMPLITUDE
23	*	INVERTED TRIANGLE AMPLITUDE
24	*	INVERTED SQUARE AMPLITUDE
25		SINE LOCKOUT LEVEL
26		TRIANGLE LOCKOUT LEVEL
27		INVERTED SINE LOCKOUT LEVEL
28		INVERTED TRIANGLE LOCKOUT LEVEL
29	*	OFFSET GAIN
30	*	HAVERSINE DC
31	*	HAVERTRIANGLE DC
32	*	HAVERSQUARE DC
33	*	INVERTED HAVERSINE DC
34	*	INVERTED HAVERTRIANGLE DC
35	*	INVERTED HAVERSQUARE DC
36		HAVERTRIANGLE MINUS PEAK LOCKOUT LEVEL
37		HAVERTRIANGLE PLUS PEAK LOCKOUT LEVEL
38		INVERTED HAVERTRIANGLE MINUS PEAK LOCKOUT
39		INVERTED HAVERTUIANGLE PLUS PEAK LOCKOUT
40	*	20DB ATTENUATOR GAIN
41	*	40DB ATTENUATOR GAIN
42		SINE BANDWIDTH
43		TRIANGLE BANDWIDTH
44		SQUARE RISE TIME AND ABBERATIONS

SECTION 4

THEORY OF OPERATION

INTRODUCTION

The Model 627 is a programable 13 MHz function generator The generator is controled by a microprocessor which allows instrument settings to be set from the front panel or via the GPIB interface. Calibration is controlled by the processor and the calibration settings are stored in non-volatile memory.

The circuitry is divided up into four printed circuit boards. The generator is on the bottom board with the output attenuators on a small board attached to the generator board. The power supply and processor are on the top board, The front panel board contains the switches and LED displays.

DISASSEMBLY

The component sides of the two main PCB's can be accessed by removing the top and bottom covers which are each held on by one screw at the rear of the instrument.

To remove the bottom PCB, first remove the covers. Then remove the bottom dress cover on the right side rail. Remove the screw attaching the attenuator shield to the side rail. Remove the screw holding the wires from the front panel to the attenuator board. Remove the 3 screws holding the generator board in. Pull on the board to release it from the connector on the controller board. The bottom of the controller board can now be accessed by removing the shield between the boards, held on by 4 screws. An extender cable is available so the unit can be operated with the generator board removed.

To remove the front panel board remove the top and bottom covers and all side rail dress covers. Loosen the screws on the side rails holding the 'L' brackets that are attached to the controller board. Loosen the screws holding the power switch bracket. Remove the screws holding the front panel top and bottom rails. Spread the side rails appart to disengage the front panel board from the side rails. Then pull the board forward to release it from the connector.

Reassemble in reverse order.

CIRCUIT DESCRIPTION

The following circuit description is divided up into sections by schematic number. The schematic number is given after the section title.

POWER SUPPLY (SCHEMATIC 1)

Line power is supplied to the instrument through the power input module which includes the input connector, fuse, line filter, line voltage switch, and connections to the power on/off switch, fan and transformer. U10 through U14 are the regulators for the various DC voltages. There are separate +5 volt supplies for the digital and analog circuits. The +5 analog, +15, and -15 volt supplies are adjusted during calibration by varying the analog control voltages to them through resistors R25, R21, and R12. Test points TP1-4 are for measuring these voltages during calibration and are located so they may be probed from the rear panel.

PROCESSOR (SCEMATIC 2)

The microprocessor U42 is a 6502 type. Its machine code program is stored in the three EPROM's U23, U24, and U25. U26 is a RAM memory with a battery built in to its own package so that it never loses its data. This allows for permanent storage during power down for instrument settings, calibration constants, GPIB address, etc. U27 is a spare RAM location not used presently. The hexadecimal addresses of the memories are shown on the schematic.

The processor is driven by a 1 MHz clock oscillator made of inverters of U34. U28 is a timer which generates the power on reset signal to th processor and other circuits.

Three busses are generated which are routed to the PROCESSOR INTERFACE which allow the processor to control the I/O ports. They are the data bus (8 lines), the address bus (16 lines), and the control bus (7 lines).

FRONT PANEL (SCHEMATIC 3)

The display consists of 4 seven segment numeric displays and 22 single LED's. They are arranged in a multiplexed array with 8 signals (left side) driving the anodes of the display segments and LED's and 7 signals (bottom) with 1 out of 8 duty cycle driving the cathodes of the numeric displays and LED's. R1 through R8 adjust for the relative brightness of the displays and LED's.

There are 15 pushbutton switches arranged also in a multiplexed array. The 4 strobe lines (bottom) are connected by the pushbuttons to the 4 sense lines (right).

PROCESSOR INTERFACE (SCHEMATIC 4)

U31 and U29 decode the address bus and generate the select signals for all the I/O ports.

U36 and U35 control the latching of data to the latches on the generator board which control analog functions. U36 makes the strobe lines for the latches. U35 latches the data and holds it for transfer to the lower board latches.

U21 is a controller which handles both the display and the pushbutton switches. Its SL signals are formed into the display cathode drivers by U17 and U18 and into the switch strobes by U16. Its RL lines are the sense lines from the pushbuttons. The A and B lines drive the display anodes through transistor arrays U19 and U20.

U43 is the controller for the GPIB interface. U44 and U45 are the tranceivers for the GPIB data and control signals.

U1 and U41 are general purpose I/O ports. Only the processor interface to them is shown here. See CONTROL VOLTAGES for their I/O circuits.

CONTROL VOLTAGES (SCHEMATIC 5)

Shown here are the I/O side of the U1 and U41 ports. U1 and 1 line of U41 are used to make the 16 control voltages which are used to control various analog circuits. U1 sends 12 bits of data to the DAC U4. U2 and U3 are analog multiplexers which route the DAC voltage to the 16 sample/hold circuits made up of hold capacitors C1-C16 and amplifiers U5, U6, U7, U8, and U9. The processor operates the select lines to the multiplexers synchronized with the data at the DAC so that the proper voltage is routed to the proper sample/hold circuit. The hold capacitors are continually updated during operation to ensure thay do not droop. The normal range of the control voltages is 0 to +2 volts, however some channels are amplified to other levels.

The COUNTER/TIMER is a circuit which measures the frequency or period of the main function generator signal. This information is used by the processor to calibrate the frequency accuracy and time symmety of the instrument. The SYNC signal runs at the generator frequency. It is fed to different frequency dividers of U37 and U38. U39 is a data selector which is controlled by the U41 I/O port and sends different divisions of the generator frequency to the measurement circuit as needed. The I/O port contains a free running timer which produces a programmable square wave at port B7 and an event counter of transitions at port B6. In the frequency counter mode the gate of U40 sees the divided frequency signal of the main generator at pin 9. A gate signal is generated by the timer at B7 and may be divided by U38 and is routed to U40 pin 10. This signal opens the gate to let the frequency get through to be counted by B6. Port B5 senses the gate signal and tells the processor when to read or reset the counter. In the timer mode, used for slower frequencies and for symmetry meqsurements, the timer B7 puts out a faster square wave sent to U40 pin 10 which is gated to the B6 counter input by the main generator signal. The counter measures the time that the gate is open. Port A0 tells the processor when the gate is open. Waveform symmetry measurements are made using the divide by 1 and the inverted divide by 1 signals.

DIP switch S1 is read by the port at different times and is used to select different operating options for the instrument.

CURRENT SOURCES (SCHEMATIC 6)

The FREQ signal from the CONTROLLER BOARD goes to the VCF amplifier, U59D, through R213. The output of U59D is used to set the current through R261. This current is fed to the input of U59D to close the feedback loop. Because of the matched characteristics of the transistors in U55, the currents in R261, R264 and R263 are all equal. The currents in R264 and R263 are summed to form the NEGATIVE CURRENT SOURCE. U59D has 2 other inputs. One is the fine frequency adjust from the CONTROLLER and the other is the VCF INPUT. The analog switches, U60B and U60C, between the VCF INPUT and U59D are there to isolate the VCF INPUT during calibration sequences.

The voltage across R261 is used to generate the POSITIVE CURRENT SOURCE. This voltage is sensed by U59A through R266. The output of U59A goes to U51 which has a current output at pin 4 proportional to the input voltage at pin 14. This current sets the voltage across R199. U50C senses this voltage and sets the voltage across R226 to the same voltage. The current through R226 is routed to the input of U59A to close the feedback loop. This curent is equal to the current in the negative current source at R261 and, because of the matching characteristics of the transistors in U55, is equal to the current through R228. The current at R228 forms the POSITIVE CURRENT SOURCE.

The two current sources must be as equal as possible to keep the symmetry of the waveform at 50%. This is adjusted by varying the feedback of U59A. This is done with the D/A converter, U64. U50A senses the current across R204 and drives the input to U64. The amount of this signal that appears at the output of U64, at pin 4, is determined by the digital input value at pins 5 through 12. U50D inverts the output of U64 and is fed to the input of U59A to form part of the feedback. the parallel combination of this circuit and R209 can be modeled as a single variable resistor with a range of 90 kohm to 110 kohm. The circuitry on the CONTROLLER BOARD can measure the symmetry and adjust it by setting the number at the inputs of latch, U65, and generating a pulse at pin 11 to latch the data so it appears at the inputs of U51. Toward the bottom of a frequency range when the currents are low and the voltages across the current setting resistors are small, the input offset of the op-amps can cause symmetry errors.

This is measured by the CONTROLLER and corrected by setting the voltage on pin 3 of U59A through R210. U51 provides for varying the symmetry of the waveform from 50% to 95% for the VARIABLE SYMMETRY mode. At 50% symmetry the digital inputs of U51 are all true (high), so all the output current is at pin 4. As the digital number is decreased, more and more of the output current appears at pin 2. This current produces a voltage across R201 and U50B causes this same voltage to appear across R229. The current through R229 is summed with the current in R226 causing U59A to decrease the current in R226 so that the sum of the two currents equals the current through R226 at 50% symmetry. With the current in R226 reduced, the current in R228 is reduced the same amount causing the POSITIVE CURRENT SOURCE to be less than the NEGATIVE CURRENT SOURCE. This produces a non-symmetrical waveform. The current in R200 equals the current in R229 and is used to keep the lockout level constant at all symmetries as described later.

On the lower frequency ranges, the frequency closely tracks the value of the current in the current sources. On the top two ranges this is not true because of the delay time of the circuitry that senses the peak of the triangle and switches the current switch, as described in a later section. This delay causes the peak to peak voltage of the triangle to grow as the frequency increases. This can be compensated for by decreasing the peak voltage that is sensed. This is done by U59B and U59C. A voltage proportional to frequency appears at analog switch, U60A, and is passed through to U59C on the top frequency range. The output of U59 is the signal that compensates the negative triangle peak. This signal is inverted by U59B to generate the positive peak compensating volatge. To adjust the amount of compensation, the gain of U59 is varied. This is done by varying the resistance of resistor FET Q39 by varying the gate voltage. The CONTROLLER BOARD measures the frequency error and adjusts this automatically. The second from the top frequency range needs only one tenth the correction. This division is acomplished by turning on U60D instead of U60A so that the voltage divider, R239 and R276, divides the input voltage by 10. On all lower ranges, both analog swithes, U60A and U60D, are off.

TIMING CAPACITORS (SCHEMATIC 7)

The generator frequency is determined by the size of the capacitor that the POSITIVE and NEGATIVE CURRENT SOURCES charge. The CONTROLLER selects one of the capacitors, C95, C96, C98 or C99 by turning on the appropriate transistor in U46. When the NEGATIVE CURRENT SOURCE is not connected to the capacitor it is routed around the capacitor to keep the transistor current and thus the voltage drop across it constant so there are no voltage steps at the peaks of the triangle. This current flows through the diode associated with each capacitor. For the top frequency range the relay, K20, is open to reduce stray capacitance and C74 becomes the timing capacitor.

For frequency ranges lower than 1kHz the CAPACITANCE MULTIPLIER is used. It is enabled by turning off relay, K21 and turning on analog switches, U58A, U58D and U56D. The current from the current sources is thus routed to U63A. this causes a voltage proportional to the current to appear at the output of U63A. The difference between this voltage and the voltage at U63B pin 5 causes a current flow through R286 which charges the capacitor, C119. The resultant voltage on C19 is buffered by U63B and is inverted by U63C. This is fed back to U63A through R291 causing the voltage at the output of U63A to track the change in voltage on C119. This keeps the voltage across R286 constant so that the voltage on C119 ramps linearly. The output of U63C is connected back to the generator loop resulting in the entire circuit acting like a 1000 uF capacitor. To make it look like a 100 uF capacitor, U56C is turned on which turns on Q53. This connects R285 in parallel with R286 and increasing the rate of charging C119 by a factor of 10. In a like manner R283 can make the capacitance 10 uF. On the .1Hz range U63D multiplies the voltage on one end of C119 by -9 and applies it to the other end of the capacitor. This makes C119 appear to be 10 uF instead of 1 uF so the capacitance of the circuit is 10000 uF.

The triangle buffer senses the voltage on the timing capacitor without distorting it. Q21A provides the high input impedance and Q20A provides the low output impedance. Q20B has the same base to emitter voltage as Q20A. Q20B is connected to Q21B to bias Q21B at a gate to source voltage equal and opposite to Q20B's base to emitter voltage. Since Q21A and Q21B are matched and running at the same current, they have equal gate to source voltages. So, the voltage at the output of the circuit equals the voltage at the input. Q33 and Q34 form an active clamp to prevent the triangle voltage from exceeding +/-1.5 volts which could result in the generator latching up.

TRIANGLE LEVEL DETECTOR AND LOCKOUT (SCHEMATIC 8)

The -1V to +1V triangle at the output of the TRIANGLE BUFFER is level shifted and attenuated to a +3V to +4V triangle, and fed to the 2 differential comparators U25B and U25C which form the LEVEL DETECTOR input stage. U25B compares the triangle to 4 volts and sets the flip-flop U26B when the triangle reachs 4 volts. U25C compares the triangle to 3 volts and resets U26B. The output of U26B at pins 14 and 15 are connected to the level shifter Q25 and Q26 which drive the current switch, U38B and U38C, to switch the NEGATIVE CURRENT SOURCE on and off. The high frequency triangle peak compensation network described earlier is connected to the reference inputs of the comparators U25B pin 9 and U25C pin 13 to bring the 3 volts and 4 volts closer together at high frequencies.

In the RUN mode, the CONTROLLER sets the inputs of U23A low to set the output high, which sets the outputs of U26A. This turns U38A off and U38D on enabling the current switch and allowing the generator to run. In the TRIGGER mode U26 is set by a trigger signal from U24 pin 14 and reset by the LEVEL DETECTOR when it switches at the triangle peak before lockout. When U26A is reset, U38A is on and pulls all the current away from Q25 and Q26. This disables the current switch by allowing the base voltage of U38B and U38C to drop to -9 volts which is below the base voltages of the lockout amplifier, U36B and U36C. The CONTROLLER sets the LOCKOUT LEVEL on the base of U36C. The triangle is on the base of U36B. When the triangle voltage is above the lockout level, U36B is on allowing the NEGATIVE CURRENT SOURCE to run the triangle negatively. When the triangle voltage is below the

lockout level U36C is on allowing the triangle to ramp positively. The LOCKOUT AMPLIFIER will stabilize with both transistors on and each drawing half the NEGATIVE CURRENT SOURCE current. In this state the positive and negative current on the timing capacitor are equal and the voltage holds. The controller can set this voltage by setting the LOCKOUT LEVEL. In the gated mode, pin 7 of U26A is held high preventing the level detector from reseting the outputs of U26A. This allows the generator to run until the gate signal goes away.

Trigger and gate signals can come from the CONTROLLER or TRIGGER INPUT. U25A is a differential comparator which compares the input voltage, at pin 5, to the 1.4 volts at pin 4. The CONTROLLER can disable external triggers by setting TRIGGER DISABLE high. Then the CONTROLLER can trigger the generater itself with a high level at INTERNAL TRIGGER. U24C shapes the trigger signal into a 10 nanosecond pulse for setting U26A. To gate the generator on for more than one cycle, U24 pin 7 is set low so gate signals are routed to U26A.

The CONTROLLER can set either - LOCKOUT or + LOCKOUT low which determines which peak of the triangle resets the LOCKOUT FLIP-FLOP at pin 6 and enables either U28C or U28D to preset the state of the LEVEL DETECTOR during lockout. This has the effect of selecting whether the triange starts up or down from the lockout state thus inverting the waveform.

SIGNAL SHAPING (SCHEMATIC 9)

The level detector drives U23B to generate differential signals for driving the SYNC OUTPUT driver. When Q48 is on, its collector voltage is about 3.5 volts and is in a low impedance state so it can drive the 50 ohm output. In the opposite state, Q49 is on which turns Q50 on and pulls the output voltage to 0 volts.

The SINE SHAPER is made up of two differential amplifiers U20A and D, and U21A and D. These are biased such that when the triangle voltage, at U20 pin 4 and U21 pin 4, is close to the reference voltage, at pins 14, they are operating in a linear mode so thier collector current is directly proportional to triangle voltage. When the

triangle voltage nears either peak, the amplifiers become nonlinear which rounds the peaks off to approximate a sinewave. One output of the SINE SHAPER at U20 pin 12 is a sinewave current. The other output, at U20 pin 12, is a minus sinewave current. The POLARITY SELECTOR, U30, selects which output is presented to the output circuitry on the next schematic. When the INVERT line is low, U30D and U30C are on. This routes the normal sine to the output and the inverted sine to ground. When INVERT is high, U30A and U30B are on. This routes the inverted sine to the output and the normal sine to ground. The CONTROLLER can optimize the operating points of the SINE SHAPER to minimize distortion. This is done by adjusting the operating currents of it by setting the voltage at U41B and by adjusting the reference voltage at U21 pin 14 by setting the voltage into U41A at R145. When other waveforms are selected, the SINE SHAPER is turned off. When the SINE line from the CONTROLLER is set low, U40D is on which pulls all the current out of the SINE SHAPER thus disabling it.

The triangle that drives the sine shaper also drives the TRIANGLE AMPLIFIER, U29A and B. This is the same type of amplifier as the sine shaper except it is biased to always operate in its linear region. It outputs a normal and inverted triangle of the same amplitude as the sinewave. It is disabled when the triangle is not selected by turning on U40C to pull all the current away from it.

The SQUARE SWITCH, U29C and U29D, recieves its inputs from the LEVEL DETECTOR through U23C. It switches all its current from one side to the other, generating squarewaves at its normal and inverted outputs. Its operating current is supplied by current source U34B. When U40D is on it is disabled.

OUTPUT CIRCUITRY (SCHEMATIC 10)

The AMPLITUDE CONTROL Circuit consists of an input amplifier, U31, a 2 quadrant analog multiplier, U33, and an output amplifier, U35. U31 recieves the current mode waveform from the POLARITY SELECTOR and converts it to a 3 volt p-p signal centered about 0 volts. The AMPLITUDE BALANCE signal from the CONTROLLER at R123 adjusts the offset of the waveform about 0 volts to obtain proper multiplication by U33. U33 multiplies the input waveform at pins 3 and 6 by the DC control voltage at pin 1 to generate an output current at pins 11 and 14 . U35 converts this current to a waveform that varies from 2 volts p-p to .2 volts p-p depending on the amount of multiplication set at U33 pin 1. Q39 gives U35 more output current drive. The amount of multiplication is set by the CONTROLLER at U41D. An optional Voltage Proportional to Amplitude INPUT allows for external control of amplitude.

The BANDWIDTH control is a resistor, R183, with a variable capacitance in parallel with it. the capacitance is supplied by the variable voltage capacitance diodes, D33 and D34. Their capacitance is varied by varying the reverse voltage accross them from 0 to 15 volts. The CONTROLLER sets this voltage to drive D33 and Q28 inverts the voltage to drive D34.

The POWER AMPLIFIER amplifies the waveform to 20 volts p-p. There are two signal paths through the amplifier. U54 is input stage for the low frequency path. Its output is connected to the emitter of Q46 to vary the current in Q46. The difference between the current in Q46 and the current in Q38 sets the voltage at their collectors. The complimentary emitter follower formed of Q45 and Q36 buffers the signal at the outputs of Q38 and Q46 to supply a drive signal for the output stage, Q40 and Q35. The signal at the emitters of the output stage is fed back to the input of the amplifier through R223 to close the feedback loop. High frequency input signals are routed around U54 through C105 and C106 to the emitter followers, Q41 and Q43. These drive the bases of Q38 and Q46 to vary their currents and thus their collector voltages in a similar manner to the low frequency stage.

The attenuators are mounted in a shield to minimize noise pick up . When there is no attenuation the output signal is routed through the 50 ohm resistor, R217 and through relay, K6. R13, R11 and R14 form a 20 dB voltage attenuator with a 50 ohm output impedance and is selected by relay, K5. R9 and R10 form a 40 dB attenuator that is selected by K4. K1 and K3 determine whether the output signal is routed to the FRONT OUTPUT or the REAR OUTPUT. U1 is the relay driver.

The OUTPUT PROTECTION circuit is an active clamp that prevents the output voltage from going beyond +/- 13 volts. Zener diode D8 senses a positive overvoltage and turns on Q1 which provides the low output impedance necessary to clamp the voltage. If the source if the overvoltage can supply over .5 amp, the output fuse,F1 or F3, will blow. D8 and Q3 protect against negative overvoltage.

SECTION 5

PARTS LIST

CONTROLLER BOARD PARTS LIST

C001	CAP POLY .1UF	0410-0011
C002	CAP POLY .1UF	0410-0011
C003	CAP POLY .1UF	0410-0011
C004	CAP POLY .1UF	0410-0011
C005	CAP POLY .1UF	0410-0011
C006	CAP POLY .1UF	0410-0011
C007	CAP POLY .1UF	0410-0011
C008	CAP POLY .1UF	0410-0011
C009	CAP POLY .1UF	0410-0011
C010	CAP POLY .1UF	0410-0011
C011	CAP POLY .1UF	0410-0011
C012	CAP POLY .1UF	0410-0011
C013	CAP POLY .1UF	0410-0011
C014	CAP POLY .1UF	0410-0011
C015	CAP POLY .1UF	0410-0011
C016	CAP POLY .1UF	0410-0011
C017	CAP POLY 1UF	0410-0033
C018	CAP CERA .1UF	0418-0008
C019	CAP CERA .01UF	0418-0014
C020	CAP CERA .1UF	0418-0008
C021	CAP CERA .1UF	0418-0008
C022	CAP CERA .1UF	0418-0008
C023	CAP CERA .001UF	0418-0016
C024	CAP CERA .1UF	0418-0008
C025	CAP ELECT 6.8UF	0403-0052
C026	CAP CERA .1UF	0418-0008
C027	CAP ELECT 6.8UF	0403-0052
C028	CAP ELECT 6.8UF	0403-0052
C029	CAP ELECT 6.8UF	0403-0052
C030	CAP ELECT 6.8UF	0403-0052
C031	CAP ELECT 1000UF	0403-0056
C032	CAP ELECT 1000UF	0403-0056
C033	CAP ELECT 6.8UF	0403-0052
C034	CAP ELECT 6.8UF	0403-0052
C035	CAP ELECT 10,000UF	0403-0021
C036	CAP POLY 1UF	0410-0033
C040	CAP CERA .1UF	0418-0008
C041	CAP ELECT 470UF	0403-0015
C042	CAP ELECT 6.8UF	0403-0052
C043	CAP ELECT 6.8UF	0403-0052
C044	CAP ELECT 6.8UF	0403-0052
C045	CAP ELECT 6.8UF	0403-0052
C046	CAP ELECT 100UF	0403-0014
C047	CAP CERA .1UF	0418-0008
C048	CAP MICA 200PF	0415-0107
C049	CAP MICA 200PF	0415-0107
C050	CAP MICA 22PF	0415-0083
C051	CAP CERA .1UF	0418-0008
C052	CAP ELECT 6.8UF	0403-0052
C053	CAP CERA .1UF	0418-0008

C054	CAP CERA .1UF	0418-0008
C055	CAP CERA .1UF	0418-0008
C056	CAP CERA .1UF	0418-0008
D001	DIODE 1N914	2101-0010
D002	DIODE 1N4001	2101-0002
D003	DIODE 1N4001	2101-0002
D004	DIODE 1N4001	2101-0002
D005	DIODE 1N4001	2101-0002
D006	DIODE DUAL MUR1605CT	2103-0010
D007	DIODE VM-18	2103-0005
J006	CONN RT/ANG GPIB	2710-0156
J011	CONN FEM 44P	2710-0155
J012	CONN FEM RT/ANG 26P	2710-0161
J022	CONN PCB 6P	2710-0011
Q001	XSTR 2N4125	2112-0003
Q002	XSTR 2N4123	2111-0007
Q003	XSTR 2N4123	2111-0007
Q004	XSTR 2N4123	2111-0007
R001	RES CC 1/4W 5% 15K	0300-1154
R002	RES MF 1/8W 1% 14.7K	0307-1174
R003	RES MF 1/8W 1% 1K	0307-1013
R004	RES MF 1/8W 1% 10K	0307-1014
R005	RES MF 1/8W 1% 10K	0307-1014
R006	RES CC 1/4W 5% 2.7K	0300-1273
R007	RES CC 1/4W 5% 1K	0300-1103
R008	RES CC 1/4W 5% 10K	0300-1104
R009	RES CC 1/4W 5% 15K	0300-1154
R010	RES CC 1/4W 5% 10K	0300-1104
R011	RES CC 1/4W 5% 100	0300-1102
R012	RES MF 1/8W 1% 383	0307-1572
R013	RES MF 1/8W 1% 383	0307-1572
R014	RES MF 1/8W 1% 2.61K	0307-1413
R015	RES MF 1/8W 1% 243	0307-1382
R016	RES MF 1/8W 1% 10K	0307-1014
R017	RES MF 1/8W 1% 10K	0307-1014
R018	RES MF 1/8W 1% 10K	0307-1014
R019	RES MF 1/8W 1% 7.5K	0307-1853
R020	RES MF 1/8W 1% 24.3K	0307-1384
R021	RES MF 1/8W 1% 383	0307-1572
R022	RES MF 1/8W 1% 383	0307-1572
R023	RES MF 1/8W 1% 2.26K	0307-1353
R024	RES MF 1/8W 1% 243	0307-1382
R025	RES MF 1/8W 1% 383	0307-1572
R026	RES MF 1/8W 1% 383	0307-1572
R027	RES MF 1/8W 1% 332	0307-1512
R028	RES MF 1/8W 1% 243	0307-1382
R029	RES CC 1/4W 5% 10K	0300-1104
R030	RES CC 1/4W 5% 10K	0300-1104
R031	RES CC 1/4W 5% 3K	0300-1303
R035	RES CC 1/4W 5% 4.7K	0300-1473
R036	RES CC 1/4W 5% 15	0300-1151
R037	RES CC 1/4W 5% 15	0300-1151
R038	RES CC 1/4W 5% 15	0300-1151
R039	RES CC 1/4W 5% 15	0300-1151
R040	RES CC 1/4W 5% 15	0300-1151

R041	RES CC 1/4W 5% 15	0300-1151
R042	RES CC 1/4W 5% 15	0300-1151
R043	RES CC 1/4W 5% 15	0300-1151
R044	RES CC 1/4W 5% 3K	0300-1303
R045	RES CC 1/4W 5% 3K	0300-1303
R046	RES CC 1/4W 5% 3K	0300-1303
R047	RES CC 1/4W 5% 3K	0300-1303
R048	RES CC 1/4W 5% 330K	0300-1335
R049	RES CC 1/4W 5% 150K	0300-1155
R050	RES CC 1/4W 5% 2K	0300-1203
R051	RES CC 1/4W 5% 2K	0300-1203
R052	RES CC 1/4W 5% 1K	0300-1103
R053	RES CC 1/4W 5% 1K	0300-1103
R054	RES CC 1/4W 5% 1K	0300-1103
RN001	RES NET SIP 10K	0317-0006
RN002	RES NET DIP 1K	0317-0012
S001	SWITCH DIP 4PST	2515-0007
TP001	TEST POINT JACK	2716-0064
TP002	TEST POINT JACK	2716-0064
TP003	TEST POINT JACK	2716-0064
TP004	TEST POINT JACK	2716-0064
TP005	TEST POINT	2714-0002
TP006	TEST POINT	2714-0002
TP007	TEST POINT	2714-0002
TP008	TEST POINT	2714-0002
TP009	TEST POINT	2714-0002
U001	IC 6522	2122-0030
U002	IC 4051	2120-0078
U003	IC 4051	2120-0078
U004	IC DAC312	2122-0040
U005	IC LF347N	2118-0095
U006	IC LF347N	2118-0095
U007	IC LF347N	2118-0095
U008	IC LF347N	2118-0095
U009	IC LF347N	2118-0095
U010	IC MC79L05ACP	2118-0016
U011	IC LM337	2118-0086
U012	IC LM317	2118-0050
U013	IC 7805	2118-0036
U014	IC LM317	2118-0050
U015	IC 78L05	2118-0070
U016	IC 74LS138	2120-0084
U017	IC MC14028BCP	2121-0046
U018	IC ULN2003A	2120-0094
U019	IC MPQ2907	2118-0106
U020	IC MPQ2907	2118-0106
U021	IC 8279	2122-0032
U023	627 EPROM 103560-1A	2122-0057
U024	627 EPROM 103560-2A	2122-0058
U025	627 EPROM 103560-3A	2122-0059
U026	IC MK48Z02B25	2121-0045
U028	IC NE555	2118-0008
U029	627 I/O DECODER 103571A	2122-0060
U030	IC 74LS139	2120-0024
U031	IC 74LS30	2120-0036

U032	IC 74LS10	2120-0027
U033	IC 74LS04	2120-0019
U034	IC 74LS04	2120-0019
U035	IC CD74HCT374E	2121-0044
U036	IC 74LS138	2120-0084
U037	IC 74LS393	2120-0096
U038	IC 74LS393	2120-0096
U039	IC 74LS151	2120-0077
U040	IC 74LS00	2120-0017
U041	IC 6522	2122-0030
U042	IC 6502	2122-0034
U043	IC 9914	2122-0033
U044	IC 75160	2120-0085
U045	IC 75161	2120-0086
Y001	CRYSTAL 1MHZ	1220-0009
ZZ001	IC SKT DIP 8P	2712-0003
ZZ002	IC SKT DIP 14P	2712-0015
ZZ003	IC SKT DIP 24P	2712-0016
ZZ004	IC SKT DIP 20P	2712-0017
ZZ005	IC SKT DIP 16P	2712-0018
ZZ006	IC SKT DIP 40P	2712-0022
ZZ007	IC SKT DIP 28P	2712-0023
ZZ008	HEATSINK TO-220	4402-0026
ZZ009	SCREW PPH 6-32x5/16	4704-2434
ZZ010	WASHER MICA #4x.800	4711-6007
ZZ011	NUT KEP 6-32x1/4	4711-9720
ZZ012	NUT PCB PRESS 6-32	4713-0014
ZZ013	SPACER #6 RND .250LG	4910-0005
ZZ014	"L" BKT TAPPED	4919-0058
ZZ015	627 CONTROLLER PCB BASIC	5201-0172

GENERATOR BOARD PARTS LIST

C001	CAP CERA .1UF	0418-0008
C004	CAP CERA .001UF	0418-0016
C005	CAP CERA .001UF	0418-0016
C006	CAP CERA .1UF	0418-0008
C008	CAP CERA .001UF	0418-0016
C009	CAP CERA .001UF	0418-0016
C010	CAP CERA .001UF	0418-0016
C011	CAP CERA .1UF	0418-0008
C013	CAP CERA .1UF	0418-0008
C014	CAP CERA .1UF	0418-0008
C020	CAP MICA 39PF	0415-0089
C021	CAP MICA 39PF	0415-0089
C024	CAP CERA .1UF	0418-0008
C025	CAP CERA .1UF	0418-0008
C026	CAP MICA 100PF	0415-0059
C028	CAP CERA .1UF	0418-0008
C029	CAP CERA .1UF	0418-0008
C030	CAP MICA 22PF	0415-0083
C033	CAP CERA .1UF	0418-0008
C034	CAP CERA .1UF	0418-0008
C035	CAP H/S CERA 7PF	0418-0055
C038	CAP CERA .1UF	0418-0008
C039	CAP CERA .1UF	0418-0008
C040	CAP CERA .1UF	0418-0008
C041	CAP MICA 100PF	0415-0059
C043	CAP MICA 47PF	0415-0091
C044	CAP MICA 100PF	0415-0059
C045	CAP CERA .1UF	0418-0008
C046	CAP MICA 100PF	0415-0059
C048	CAP CERA .1UF	0418-0008
C049	CAP CERA .1UF	0418-0008
C050	CAP CERA .001UF	0418-0016
C051	CAP MICA 100PF	0415-0059
C053	CAP MICA 1000PF	0415-0126
C054	CAP MICA 1PF	0415-0074
C055	CAP ELECT 6.8UF	0403-0052
C056	CAP ELECT 6.8UF	0403-0052
C058	CAP ELECT 6.8UF	0403-0052
C059	CAP CERA .1UF	0418-0008
C060	CAP H/S CERA 7PF	0418-0055
C061	CAP MICA 100PF	0415-0059
C063	CAP CERA .1UF	0418-0008
C064	CAP CERA .1UF	0418-0008
C065	CAP CERA .1UF	0418-0008
C066	CAP CERA .001UF	0418-0016
C068	CAP CERA .001UF	0418-0016
C071	CAP MICA 300PF	0415-0070
C073	CAP CERA .001UF	0418-0016
C074	CAP H/S CERA 56PF	0418-0068
C075	CAP CERA .1UF	0418-0008

C076	CAP CERA .1UF	0418-0008
C078	CAP CERA .1UF	0418-0008
C079	CAP CERA .1UF	0418-0008
C080	CAP CERA .001UF	0418-0016
C081	CAP CERA .1UF	0418-0008
C083	CAP CERA .001UF	0418-0016
C084	CAP CERA .1UF	0418-0008
C085	CAP CERA .001UF	0418-0016
C086	CAP ELECT 6.8UF	0403-0052
C088	CAP CERA .001UF	0418-0016
C089	CAP ELECT 6.8UF	0403-0052
C090	CAP CERA .001UF	0418-0016
C091	CAP ELECT 6.8UF	0403-0052
C093	CAP CERA .1UF	0418-0008
C094	CAP CERA .001UF	0418-0016
C095	CAP POLY .00091UF	0410-0036
C096	CAP POLY .01UF	0410-0038
C098	CAP POLY .1UF	0410-0039
C099	CAP POLY 1UF	0410-0040
C101	CAP ELECT 6.8UF	0403-0052
C103	CAP MICA 10PF	0415-0078
C104	CAP CERA .1UF	0418-0008
C105	CAP CERA .01UF	0418-0014
C106	CAP CERA .01UF	0418-0014
C108	CAP ELECT 6.8UF	0403-0052
C109	CAP CERA .001UF	0418-0016
C110	CAP ELECT 6.8UF	0403-0052
C111	CAP CERA .001UF	0418-0016
C113	CAP ELECT 6.8UF	0403-0052
C114	CAP MICA 1000PF	0415-0126
C116	CAP ELECT 6.8UF	0403-0052
C118	CAP CERA .01UF	0418-0014
C119	CAP POLY 1UF	0410-0040
C120	CAP MICA 470PF	0415-0117
C121	CAP CERA .1UF	0418-0008
C123	CAP MICA 10PF	0415-0078
C124	CAP CERA .1UF	0418-0008
C125	CAP MICA 470PF	0415-0117
C126	CAP MICA 270PF	0415-0111
C128	CAP CERA .01UF	0418-0014
C129	CAP MICA 100PF	0415-0059
C130	CAP CERA .001UF	0418-0016
C131	CAP CERA .001UF	0418-0016
C133	CAP CERA .001UF	0418-0016
C134	CAP CERA .001UF	0418-0016
D001	DIODE 1N963	2101-0022
D003	DIODE 1N4005	2101-0005
D004	DIODE 1N4005	2101-0005
D005	DIODE 1N4005	2101-0005
D006	DIODE 1N4005	2101-0005
D008	DIODE 1N963	2101-0022
D009	DIODE 1N914	2101-0010
D010	DIODE 1N914	2101-0010
D020	DIODE 1N914	2101-0010
D021	DIODE 1N914	2101-0010

D023	DIODE 1N914	2101-0010
D024	DIODE 1N914	2101-0010
D025	DIODE 1N914	2101-0010
D026	DIODE 1N825A	2102-0033
D028A	DIODE SET 1N825A	2104-0008
D028B	DIODE SET 1N825B	2104-0008
D030	DIODE 1N914	2101-0010
D031	DIODE 1N914	2101-0010
D032	DIODE ZENER 1N753A 6.2V	2101-0023
D033	DIODE VAR MV209	2101-0027
D034	DIODE VAR MV209	2101-0027
D035	DIODE 1N914	2101-0010
D036	DIODE 1N914	2101-0010
D038	DIODE 1N914	2101-0010
D039	DIODE 1N914	2101-0010
D040	DIODE 1N914	2101-0010
D041	DIODE 1N914	2101-0010
D043	DIODE 1N914	2101-0010
D044	DIODE 1N914	2101-0010
D045	DIODE 1N914	2101-0010
D046	DIODE 1N914	2101-0010
D048	DIODE 1N914	2101-0010
D049	DIODE 1N914	2101-0010
D050	DIODE 1N914	2101-0010
D051	DIODE 1N914	2101-0010
D053	DIODE 1N914	2101-0010
D054	DIODE 1N914	2101-0010
D055	DIODE 1N914	2101-0010
D056	DIODE 1N963	2101-0022
D058	DIODE 1N4001	2101-0002
D059	DIODE 1N914	2101-0010
D060	DIODE 1N914	2101-0010
D063	DIODE 5082-2811	2101-0023
D064	DIODE 1N914	2101-0010
D065	DIODE 1N914	2101-0010
F001	FUSE PICO 1/2A	1005-0103
F003	FUSE PICO 1/2A	1005-0103
J013	CONN PCB 2P	2710-0007
J014	CONN PCB 2P	2710-0007
J015	CONN PCB 2P	2710-0007
J016	CONN PCB 2P	2710-0007
J017	CONN PCB 2P	2710-0007
J018	CONN PCB 2P	2710-0007
J019	CONN PCB 2P	2710-0007
J020	CONN PCB 2P	2710-0007
J021	CONN PCB 2P	2710-0007
J023	CONN HDR 8P	2710-0159
K001	RELAY SPST	2560-0006
K003	RELAY SPST	2560-0006
K004	RELAY SPST	2560-0006
K005	RELAY SPST	2560-0006
K006	RELAY SPST	2560-0006
K020	RELAY SPST	2560-0006
K021	RELAY SPST	2560-0006
L020	FERRITE BEAD	1238-0008

P011	CONN MALE 44P	2710-0157
P023	CONN PCB THRU 8P	2710-0158
Q001	XSTR 2N4921	2111-0027
Q003	XSTR 2N4918	2112-0026
Q020A	XSTR SET MPS3646	2115-0002
Q020B	XSTR SET MPS3646	2115-0002
Q021A	XSTR SET 2N5458	2115-0011
Q021B	XSTR SET 2N5458	2115-0011
Q023	XSTR 2N4258	2112-0025
Q024	XSTR MPS3563	2111-0023
Q025	XSTR 2N4258	2112-0025
Q026	XSTR 2N4258	2112-0025
Q028	XSTR 2N2484	2111-0021
Q029	XSTR MPS3646	2111-0005
Q030	XSTR MPS6544	2111-0035
Q031	XSTR MPS6544	2111-0035
Q033	XSTR MPS3563	2111-0023
Q035	XSTR 2N2905	2112-0019
Q036	XSTR 2N4121	2112-0022
Q038	XSTR MPS6544	2111-0035
Q039	FET VCR3P	2114-0009
Q040	XSTR 2N2219	2111-0020
Q041	XSTR 2N4121	2112-0022
Q043	XSTR MPS6544	2111-0035
Q044	XSTR 2N4250	2112-0023
Q045	XSTR MPS6544	2111-0035
Q046	XSTR 2N4121	2112-0022
Q048	XSTR 2N3905	2112-0007
Q049	XSTR 2N3905	2112-0007
Q050	XSTR MPS3646	2111-0005
Q051	FET J271	2114-0026
Q053	FET J271	2114-0026
R001	RES CC 1/4W 5% 200	0300-1202
R005	RES CC 1/4W 5% 200	0300-1202
R006	RES CC 1/4W 5% 1.3K	0300-1133
R008	RES CC 1/4W 5% 1.3K	0300-1133
R009	RES MF 1/2W 1% 49.9	0309-1681
R010	RES MF 1/8W 1% 4.99K	0307-1683
R011	RES CC 1/4W 5% 5.6	0300-1560
R013	RES MF 1/4W 1% 499	0308-1682
R014	RES MF 1/2W 1% 49.9	0309-1681
R015	RES MF 1/2W 1% 49.9	0309-1681
R020	RES MF 1/8W 1% 1.1K	0307-1053
R021	RES MF 1/8W 1% 10K	0307-1014
R022	RES CC 1/4W 5% 100	0300-1102
R023	RES MF 1/8W 1% 80.6	0307-1881
R024	RES MF 1/8W 1% 80.6	0307-1881
R025	RES MF 1/8W 1% 46.4	0307-1651
R026	RES CC 1/4W 5% 47	0300-1471
R027	RES CC 1/4W 5% 100	0300-1102
R028	RES CC 1/4W 5% 47	0300-1471
R029	RES MF 1/8W 1% 46.4	0307-1651
R030	RES MF 1/8W 1% 100	0307-1012
R031	RES MF 1/8W 1% 4.02K	0307-1593
R033	RES MF 1/8W 1% 1.58K	0307-1203

R034	RES MF 1/8W 1% 1.05K	0307-1033
R036	RES MF 1/8W 1% 4.02K	0307-1593
R038	RES MF 1/8W 1% 12.7K	0307-1114
R039	RES MF 1/8W 1% 12.1K	0307-1094
R040	RES MF 1/8W 1% 1K	0307-1013
R041	RES MF 1/8W 1% 4.02K	0307-1593
R043	RES MF 1/8W 1% 3.09K	0307-1483
R044	RES MF 1/8W 1% 4.02K	0307-1593
R045	RES MF 1/8W 1% 3.83K	0307-1573
R046	RES MF 1/8W 1% 332	0307-1512
R048	RES MF 1/8W 1% 249	0307-1392
R049	RES MF 1/8W 1% 576	0307-1742
R050	RES MF 1/8W 1% 1.37K	0307-1143
R051	RES MF 1/8W 1% 499	0307-1682
R053	RES MF 1/8W 1% 1.69K	0307-1233
R054	RES MF 1/8W 1% 1.69K	0307-1233
R055	RES MF 1/8W 1% 1.54K	0307-1193
R056	RES MF 1/8W 1% 1.54K	0307-1193
R058	RES CC 1/4W 5% 100	0300-1102
R059	RES CC 1/4W 5% 10	0300-1101
R060	RES CC 1/4W 5% 100	0300-1102
R061	RES CC 1/4W 5% 100	0300-1102
R063	RES CC 1/4W 5% 100	0300-1102
R064	RES CC 1/4W 5% 150	0300-1152
R065	RES CC 1/4W 5% 150	0300-1152
R066	RES MF 1/8W 1% 1.69K	0307-1233
R068	RES MF 1/8W 1% 374	0307-1562
R069	RES CC 1/4W 5% 2K	0300-1203
R070	RES CC 1/4W 5% 10K	0300-1104
R071	RES CC 1/4W 5% 1K	0300-1103
R073	RES CC 1/4W 5% 100	0300-1102
R074	RES MF 1/8W 1% 1K	0307-1013
R075	RES MF 1/8W 1% 4.02K	0307-1593
R076	RES MF 1/8W 1% 19.1K	0307-1284
R078	RES MF 1/8W 1% 2K	0307-1303
R079	RES MF 1/8W 1% 340	0307-1522
R080	RES MF 1/8W 1% 200	0307-1302
R081	RES CC 1/4W 5% 100	0300-1102
R083	RES MF 1/8W 1% 5.49K	0307-1723
R084	RES MF 1/8W 1% 3.48K	0307-1533
R085	RES MF 1/8W 1% 5.49K	0307-1723
R086	RES MF 1/8W 1% 11.5K	0307-1074
R088	RES CC 1/4W 5% 33	0300-1331
R089	RES MF 1/8W 1% 402	0307-1592
R090	RES MF 1/8W 1% 499	0307-1682
R091	RES MF 1/8W 1% 2K	0307-1303
R093	RES CC 1/4W 5% 2.7K	0300-1273
R094	RES CC 1/4W 5% 680	0300-1682
R095	RES CC 1/4W 5% 100	0300-1102
R096	RES CC 1/4W 5% 100	0300-1102
R098	RES CC 1/4W 5% 100	0300-1102
R099	RES CC 1/4W 5% 100	0300-1102
R100	RES CC 1/4W 5% 680	0300-1682
R101	RES CC 1/4W 5% 2.7K	0300-1273
R103	RES MF 1/8W 1% 590	0307-1752

R104	RES MF 1/8W 1% 499	0307-1682
R105	RES CC 1/4W 5% 560	0300-1562
R106	RES MF 1/8W 1% 66.5	0307-1801
R108	RES MF 1/8W 1% 66.5	0307-1801
R109	RES CC 1/4W 5% 200	0300-1202
R110	RES MF 1/8W 1% 110	0307-1052
R111	RES MF 1/8W 1% 4.02K	0307-1593
R113	RES MF 1/8W 1% 4.02K	0307-1593
R114	RES CC 1/4W 5% 1.1K	0300-1113
R115	RES MF 1/8W 1% 28K	0307-1444
R116	RES MF 1/8W 1% 1.21K	0307-1093
R118	RES CC 1/4W 5% 100	0300-1102
R119	RES MF 1/8W 1% 2.37K	0307-1373
R121	RES CC 1/4W 5% 620	0300-1622
R123	RES MF 1/8W 1% 2.80K	0307-1443
R124	RES MF 1/8W 1% 1.78K	0307-1253
R125	RES CC 1/4W 5% 51	0300-1511
R126	RES MF 1/8W 1% 28K	0307-1444
R128	RES CC 1/4W 5% 100	0300-1102
R129	RES MF 1/8W 1% 1.3K	0307-1123
R130	RES CC 1/4W 5% 1K	0300-1103
R131	RES MF 1/8W 1% 1.1K	0307-1053
R133	RES MF 1/8W 1% 1.1K	0307-1053
R134	RES CC 1/4W 5% 100	0300-1102
R135	RES MF 1/8W 1% 32.4	0307-1501
R136	RES MF 1/8W 1% 32.4	0307-1501
R138	RES MF 1/8W 1% 68.1	0307-1811
R139	RES MF 1/8W 1% 68.1	0307-1811
R140	RES MF 1/8W 1% 287	0307-1452
R141	RES CC 1/4W 5% 100	0300-1102
R143	RES CC 1/4W 5% 100	0300-1102
R144	RES MF 1/8W 1% 12.4K	0307-1104
R145	RES MF 1/8W 1% 2K	0307-1303
R146	RES MF 1/8W 1% 4.53K	0307-1643
R148	RES MF 1/8W 1% 4.53K	0307-1643
R149	RES MF 1/8W 1% 11.5K	0307-1074
R150	RES MF 1/8W 1% 3.16K	0307-1493
R151	RES CC 1/4W 5% 4.7K	0300-1473
R153	RES CC 1/4W 5% 4.7K	0300-1473
R154	RES CC 1/4W 5% 4.7K	0300-1473
R155	RES CC 1/4W 5% 10K	0300-1104
R156	RES CC 1/2W 5% 910	0301-1912
R158	RES CC 1/4W 5% 100	0300-1102
R159	RES CC 1/4W 5% 27	0300-1271
R160	RES CC 1/4W 5% 27	0300-1271
R161	RES MF 1/8W 1% 12.4K	0307-1104
R163	RES MF 1/8W 1% 2.49K	0307-1393
R164	RES CC 1/4W 5% 2.2K	0300-1223
R165	RES CC 1/4W 5% 10K	0300-1104
R166	RES CC 1/4W 5% 100	0300-1102
R168	RES CC 1/4W 5% 100	0300-1102
R169	RES CC 1/4W 5% 330	0300-1332
R170	RES MF 1/8W 1% 9.09K	0307-1933
R171	RES MF 1/8W 1% 7.5K	0307-1853
R173	RES CC 1/4W 5% 1.1K	0300-1113

R174	RES CC 1/4W 5% 910	0300-1912
R175	RES CC 1/4W 5% 100	0300-1102
R176	RES CC 1/4W 5% 100	0300-1102
R178	RES CC 1/4W 5% 3K	0300-1303
R179	RES CC 1/4W 5% 100	0300-1102
R183	RES MF 1/8W 1% 226	0307-1352
R184	RES CC 1/4W 5% 2K	0300-1203
R185	RES CC 1/4W 5% 1K	0300-1103
R186	RES CC 1/2W 5% 10	0301-1101
R188	RES CC 1/2W 5% 15	0301-1151
R189	RES CC 1/4W 5% 27	0300-1271
R190	RES CC 1/4W 5% 200	0300-1202
R191	RES CC 1/4W 5% 560	0300-1562
R193	RES CC 1/4W 5% 100	0300-1102
R194	RES CC 1/4W 5% 47	0300-1471
R195	RES MF 1/8W 1% 2.43K	0307-1383
R196	RES MF 1/8W 1% 4.22K	0307-1613
R198	RES MF 1/8W 1% 324	0307-1502
R199	RES MF 1/8W 1% 2K	0307-1303
R200	RES MF 1/8W 1% 732	0307-1842
R201	RES MF 1/8W 1% 2K	0307-1303
R203	RES CC 1/4W 5% 7.5M	0300-1756
R204	RES MF 1/8W 1% 374	0307-1562
R205	RES MF 1/8W 1% 10K	0307-1014
R206	RES MF 1/8W 1% 1K	0307-1013
R208	RES MF 1/8W 1% 499K	0307-1685
R209	RES MF 1/8W 1% 110K	0307-1055
R210	RES MF 1/8W 1% 10K	0307-1014
R211	RES MF 1/8W 1% 249	0307-1392
R213	RES MF 1/8W 1% 2.61K	0307-1413
R214	RES MF 1/8W 1% 165K	0307-1225
R215	RES CC 1/2W 5% 10	0301-1101
R216	RES CC 1/2W 5% 15	0301-1151
R217	INSUL JUMPER 1.000	3015-0009
R218	RES CC 1/4W 5% 68	0300-1681
R219	RES CC 1/4W 5% 27	0300-1271
R220	RES CC 1/4W 5% 56	0300-1561
R221	RES MF 1/8W 1% 25.5K	0307-1404
R223	RES MF 1/8W 1% 2.15K	0307-1333
R224	RES CC 1/4W 5% 1K	0300-1103
R225	RES MF 1/8W 1% 1M	0307-1016
R226	RES MF 1/8W 1% 732	0307-1842
R228	RES MF 1/8W 1% 732	0307-1842
R229	RES MF 1/8W 1% 732	0307-1842
R230	RES MF 1/8W 1% 75K	0307-1854
R231	RES MF 1/8W 1% 49.9	0307-1681
R233	RES CC 1/4W 5% 2K	0300-1203
R234	RES MF 1/8W 1% 2K	0307-1303
R235	RES MF 1/8W 1% 1.24M	0307-1106
R236	RES MF 1/8W 1% 5.62K	0307-1733
R238	RES MF 1/8W 1% 1K	0307-1013
R239	RES MF 1/8W 1% 100K	0307-1015
R240	RES CC 1/4W 5% 100	0300-1102
R241	RES CC 1/4W 5% 560	0300-1562
R243	RES CC 1/4W 5% 75	0300-1751

R244	RES CC 1/4W 5% 47	0300-1471
R245	RES MF 1/8W 1% 2.43K	0307-1383
R246	RES CC 1/4W 5% 750	0300-1752
R248	RES CC 1/4W 5% 33	0300-1331
R249	RES CC 1/4W 5% 33	0300-1331
R250	RES CC 1/4W 5% 100	0300-1102
R251	RES CC 1/4W 5% 330	0300-1332
R253	RES MF 1/8W 1% 13.7K	0307-1144
R254	RES MF 1/8W 1% 3.01K	0307-1473
R255	RES MF 1/8W 1% 13.7K	0307-1144
R256	RES CC 1/4W 5% 100	0300-1102
R258	RES MF 1/8W 1% 100K	0307-1015
R259	RES MF 1/8W 1% 4.99K	0307-1683
R260	RES MF 1/8W 1% 8.06K	0307-1883
R261	RES MF 1/8W 1% 732	0307-1842
R263	RES MF 1/8W 1% 732	0307-1842
R264	RES MF 1/8W 1% 732	0307-1842
R265	RES CC 1/4W 5% 2K	0300-1203
R266	RES MF 1/8W 1% 100K	0307-1015
R268	RES MF 1/8W 1% 4.75K	0307-1663
R269	RES MF 1/8W 1% 1K	0307-1013
R270	RES CC 1/4W 5% 100	0300-1102
R271	RES MF 1/8W 1% 475	0307-1662
R273	RES MF 1/8W 1% 10K	0307-1014
R274	RES MF 1/8W 1% 10K	0307-1014
R275	RES MF 1/8W 1% 14.7K	0307-1174
R276	RES MF 1/8W 1% 11K	0307-1054
R278	RES CC 1/4W 5% 270	0300-1272
R279	RES CC 1/2W 5% 47	0301-1471
R280	RES CC 1/2W 5% 47	0301-1471
R281	RES CC 1/4W 5% 10K	0300-1104
R283	RES MF 1/8W 1% 10K	0307-1014
R284	RES CC 1/4W 5% 10K	0300-1104
R285	RES MF 1/8W 1% 110K	0307-1055
R286	RES MF 1/8W 1% 1M	0307-1016
R288	RES MF 1/8W 1% 10K	0307-1014
R289	RES MF 1/8W 1% 90.9K	0307-1934
R290A	RES SET 1K	0316-0101
R290B	RES SET 1K	0316-0101
R293A	RES SET 1K	0316-0101
R293B	RES SET 1K	0316-0101
R295	RES MF 1/8W 1% 374K	0307-1565
R296	RES MF 1/8W 1% 4.99K	0307-1683
R298	RES CC 1/4W 5% 620	0300-1622
RN020	RES NET SIP 680	0317-0011
RN021	RES NET SIP 680	0317-0011
RN023	RES NET DIP 1K	0317-0012
RN024	RES NET DIP 3.3K	0317-0013
RN025	RES NET SIP 1.8K	0317-0010
RN026	RES NET DIP 1K	0317-0012
TP020	TEST POINT	2714-0002
TP021	TEST POINT	2714-0002
TP023	TEST POINT	2714-0002
TP024	TEST POINT	2714-0002
U001	IC 7417	2120-0071

U003	IC 78L05	2118-0070
U020	IC CA3127E	2118-0107
U021	IC CA3127E	2118-0107
U023	IC MC10105	2121-0057
U024	IC MC10102	2121-0055
U025	IC MC10116	2121-0047
U026	IC MC10131	2121-0062
U028	IC MC10102	2121-0055
U029	IC MPQ2369	2118-0109
U030	IC MPQ2369	2118-0109
U031	IC NE5539	2118-0110
U033	IC AD539JD	2118-0108
U034	IC MPQ2369	2118-0109
U035	IC NE5539	2118-0110
U036	IC MPQ2369	2118-0109
U038	IC MPQ2369	2118-0109
U040	IC MPQ3798	2118-0111
U041	IC LF347N	2118-0095
U043	IC MC79L05ACP	2118-0016
U044	IC CD74HCT374E	2121-0044
U045	IC CD74HCT374E	2121-0044
U046	IC MPQ3798	2118-0111
U048	IC 78L05	2118-0070
U049	IC CA3096	2118-0077
U050	IC LF347N	2118-0095
U051	IC DAC08	2118-0044
U053	IC CD74HCT374E	2121-0044
U054	IC LF356N	2118-0053
U055	IC CA3096	2118-0077
U056	IC LF13202	2118-0054
U058	IC LF13202	2118-0054
U059	IC LF347N	2118-0095
U060	IC LF13202	2118-0054
U061	IC CD74HCT374E	2121-0044
U063	IC LF347N	2118-0095
U064	IC DAC08	2118-0044
U065	IC CD74HCT374E	2121-0044
U066	IC CD74HCT374E	2121-0044
W020	INSUL JUMPER .500	3015-0007
ZZ001	627 GENERATOR PCB BASIC	5201-0173
ZZ002	HEATSINK FINNED	4402-0010
ZZ003	XSTR PAD 7717-5	4906-0001
ZZ004	IC SKT DIP 8P	2712-0003
ZZ005	IC SKT DIP 14P	2712-0015
ZZ006	IC SKT DIP 16P	2712-0018
ZZ007	IC SKT DIP 20P	2712-0017
ZZ008	PRESS NUT PCB 6-32	4713-0014
ZZ009	627 ATTN SHIELD ASSY	5215-0176
ZZ010	GROUND LUG	2716-0073

SECTION 6

SCHEMATICS

DAMAGE & SHORTAGE

Before you fully unpack any unit READ THIS for your protection

(THIS INFORMATION APPLIES ONLY ON SHIPMENTS WITHIN THE UNITED STATES)

DAMAGE This shipment was packaged and delivered to the carrier with the utmost care to insure safe delivery of goods. When shipment is received and signed for by the transportation company, consignor's responsibility ceases. Do not accept shipment which evidences damage or shortage until agent of carrier endorses a statement of the irregularity on the face of the transportation receipt. Without documentary evidence, claim cannot be filed.

CONCEALED DAMAGE Interstate Commerce Commission has indicated that a carrier is as much responsible for concealed damage as for visible damage in transit. Upon receipt of shipment, promptly unpack and check thoroughly. If concealed damage is discovered, cease further unpacking and request immediate inspection by local agent of carrier. A written report of the agent's findings, with his signature, is necessary to support claim.

SHORTAGE Check shipment against shipping papers. Do not discard packing materials or packing cases until contents have been found to be correct. The removal of badly needed items, before shipment has been checked, may create a shortage. Check all possibilities before reporting a shortage.

CLAIMS If your agent or carrier has been given an opportunity to inspect the shipment, any claim for a shortage or damaged merchandise can be handled as a simple and routine procedure. Claims must be filed by consignee. Shipping terms are f.o.b. Carson City, Nevada.

LOSS In the event of complete loss, claim will be handled in the same manner as for Shipping Damage or Shortage.

**Note further information below.*

SHIPPING DAMAGE OR SHORTAGE

AIR FREIGHT – Claim must be initiated at point of destination. Claim must be filed by submitting a letter on company stationery with an explanation of the extent of damage or loss and forwarded with a copy of the original* air bill, and original invoice or photostat of same, to the airline having carried the shipment.

*Upon request certified photostatic copies of original papers held by Dynatech-Nevada required in support of port of claims will be made available.

PARCEL POST / UPS

PLACING CLAIM FOR DAMAGE – For those shipments insured by Parcel Post, the addressee initiates the claim by filling out Post Office Dept. Form 3812, "Request for Payment of Domestic Postal Insurance". Item 12 is to be other than Dynatech-Nevada. Damaged material must be returned to the Post Office of address for inspection. A new purchase order is required by Dynatech-Nevada to cover the cost of repairs (or in the case of loss or refiling-replacement order). Damaged material will be repaired and returned. Party named in item 12 of form 3812 will receive reimbursement for repair cost from Post Office Department.

PLACING CLAIM FOR LOSS – In the event of a report to consignor of loss or refiling, Post Office Dept. Form 3812 will be initiated by Dynatech-Nevada at point of origin. If, after Post Office investigation, the material is not located, disposition from this point will be the same as stated in the above paragraph—"Placing claim for damage."

PLACING CLAIM FOR DAMAGE TO SHIPMENTS BY UNITED PARCEL—The addressee must notify Dynatech-Nevada, who will notify United Parcel Service giving the shipper's number and date parcel was shipped. United Parcel Service will send a representative to inspect the damage and advise proper disposition. A new purchase order is required by Dynatech-Nevada to cover the cost of repairs or in the case of loss or refiling, a replacement order. Damaged material will be repaired and returned.

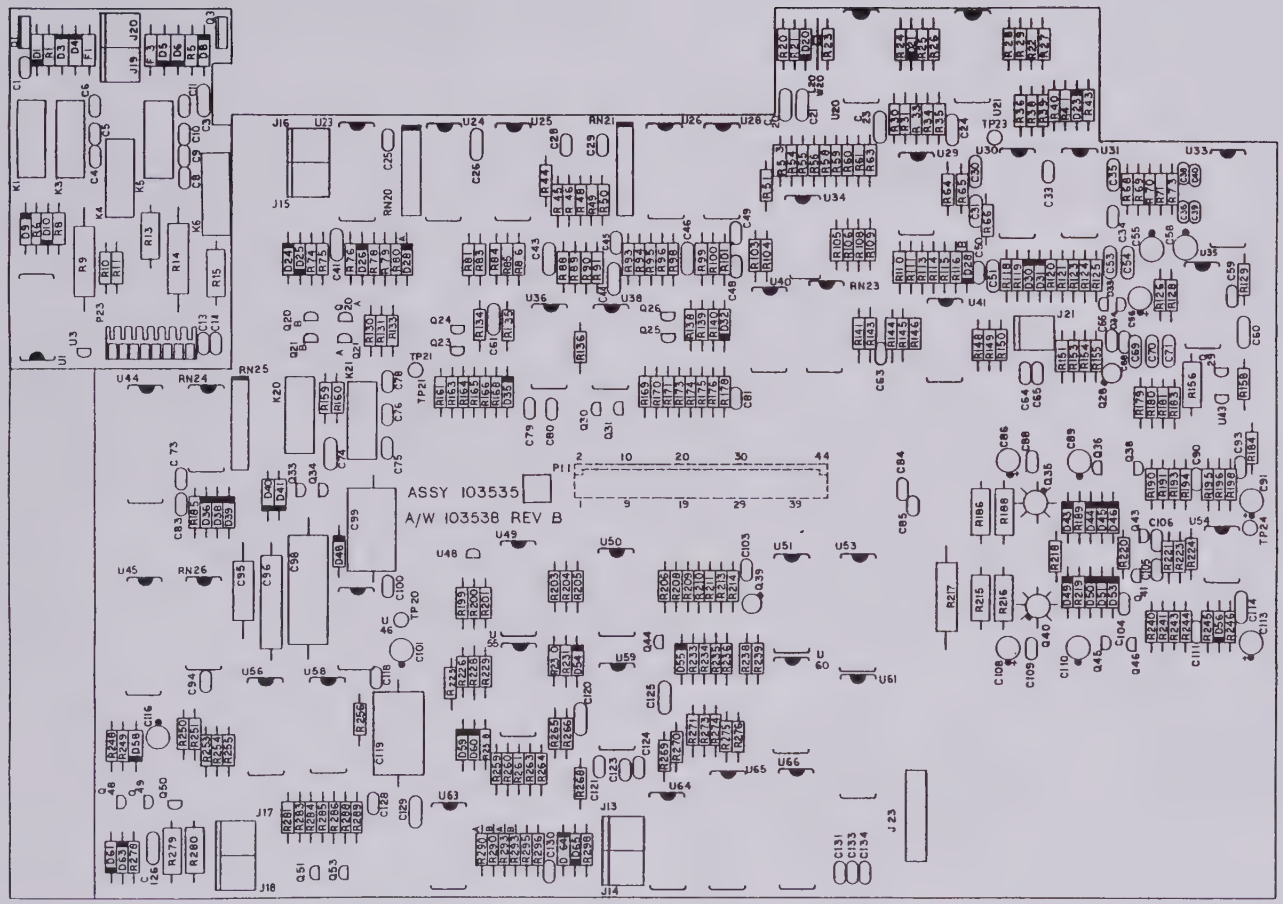
DYNATECH NEVADA
INCORPORATED

Formerly NEURODYNE-DEMPSEY

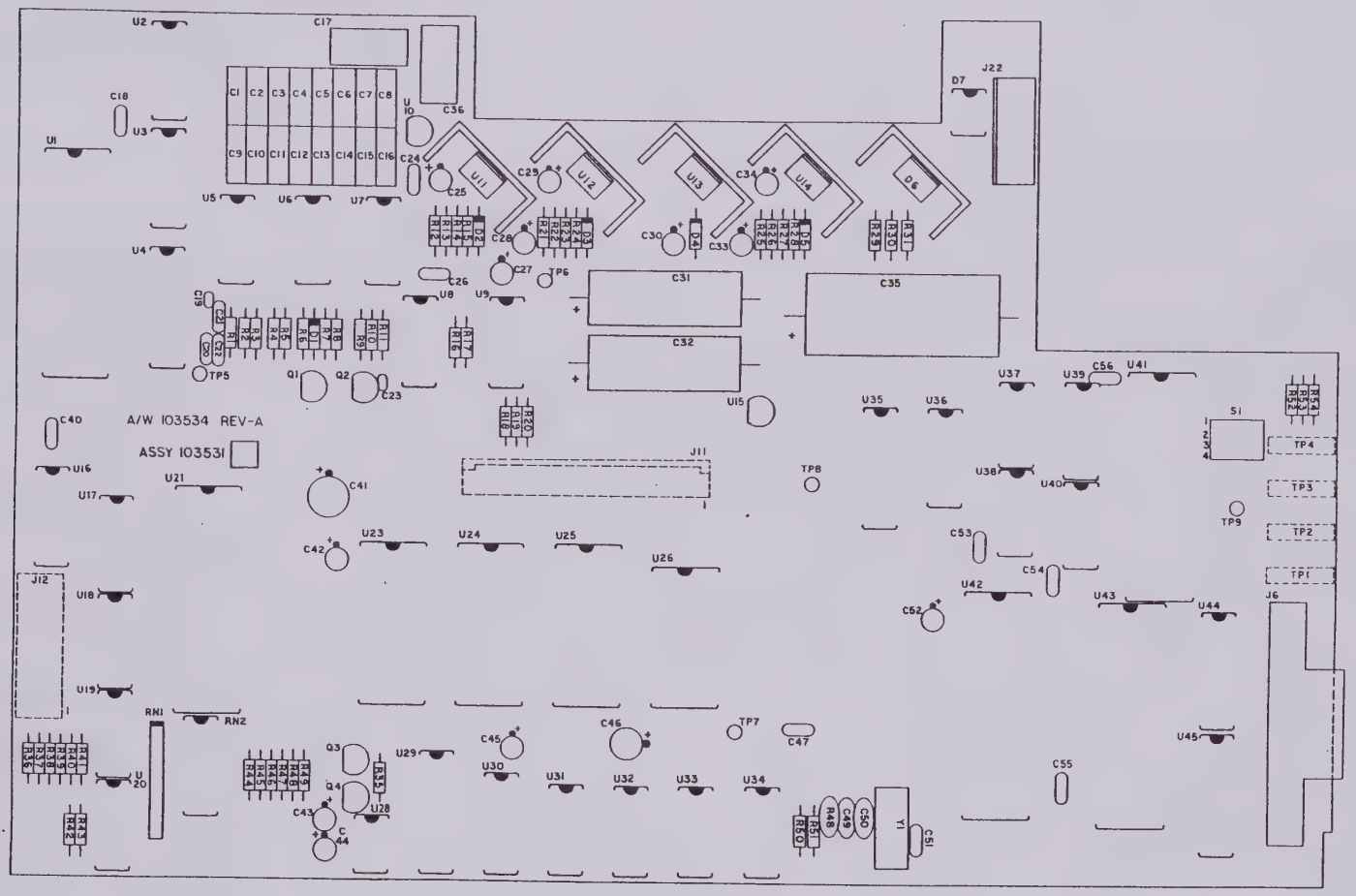
2000 ARROWHEAD DRIVE, P.O. BOX 1925, CARSON CITY, NEVADA 89701 (702) 883-3400

Data Sheet 1003 · 8/79 PRINTED IN U.S.A.

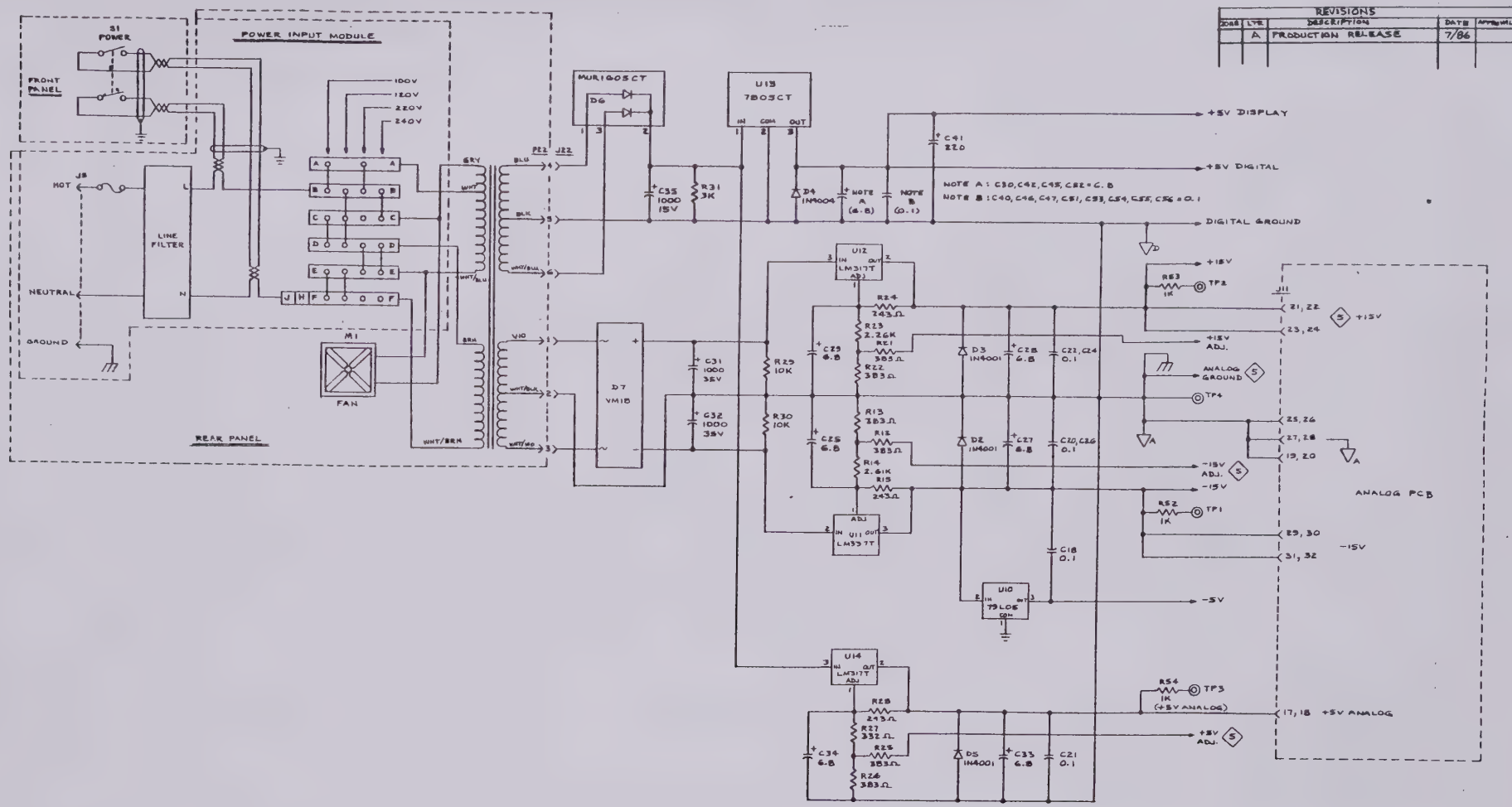
REV B CORRECTED ERRORS RF 4/23/86



		INTERPRET THIS DRAWING PER STANDARD MIL-D-1000	DM 4-85	DYNATECH NEVADA INCORPORATED CARSON CITY NEVADA
		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		TITLE 627 GENERATOR PCB REF DEG A/W
		Tolerances on: Fractions ± .01 (in.) Angles ± 1/2° Decimals .X ± .25 .XX ± .10 .XXX ± .005		SIZE D DRAWING NO 103538 REV B
NEXT ASSEMBLY	USED ON	MATERIAL	APPROVED	SCALE 2-1 WEIGHT SHEET 1 OF 1
APPLICATION			APPROVED	



NEXT ASSEMBLY	USED ON	MATERIAL	DM	3-86	DYNATECH NEVADA INCORPORATED
APPLICATION			APPROVED		TITLE: 627 CONTROLLER PCB REF DEG A/W
			APPROVED		SIZE D · DRAWING NO 103534 · REV A · SCALE 2-1 · WEIGHT ~ · SHEET 1 OF 1



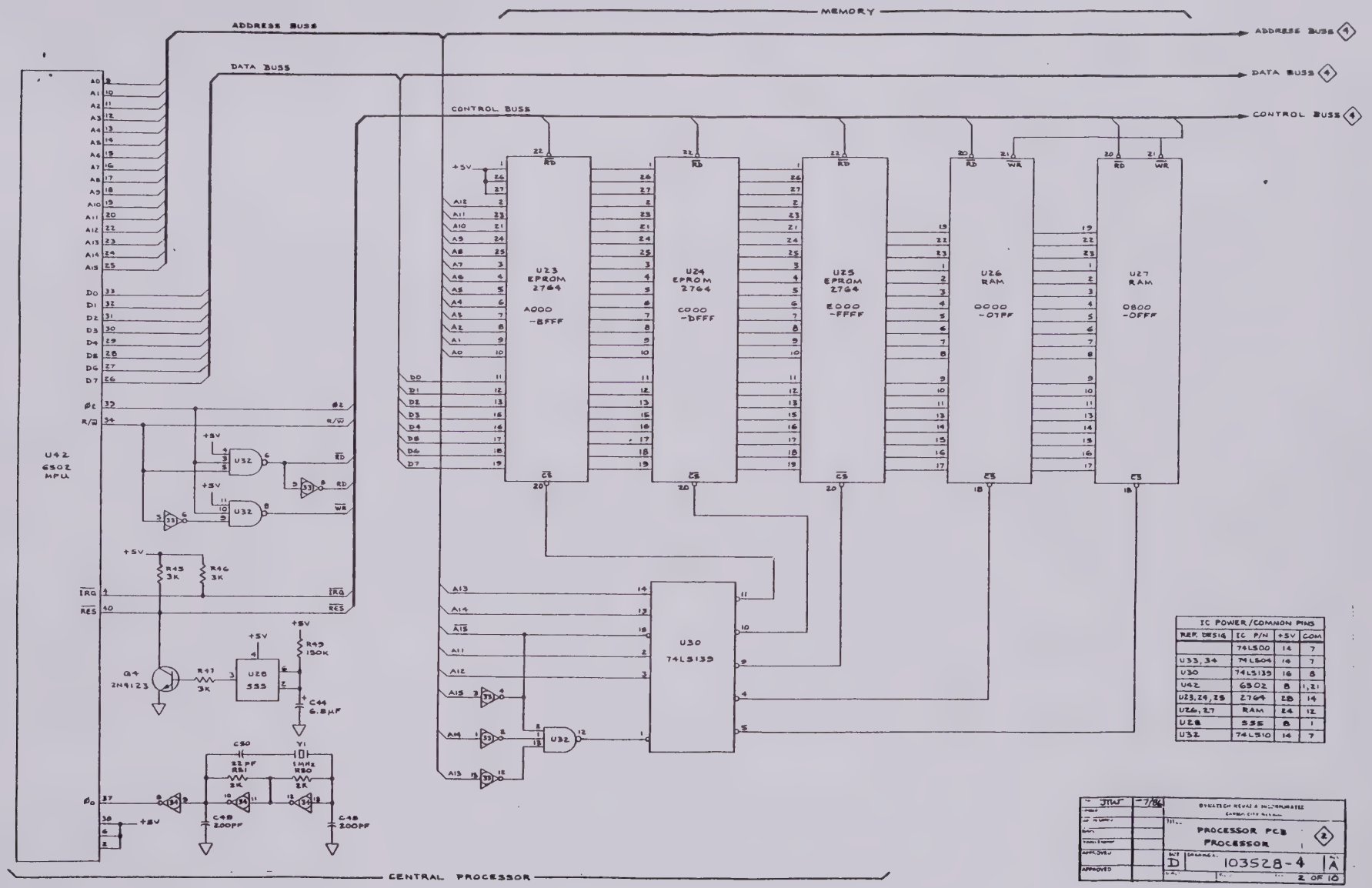
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	PRODUCTION RELEASE	7/86	

DRAWN	JTW	7/86
CHECKED		
QUALITY ENGR		
PROJECT ENGR		
APPROVED		

DIGITECH NEVADA INCORPORATED
CARSON CITY NEVADA

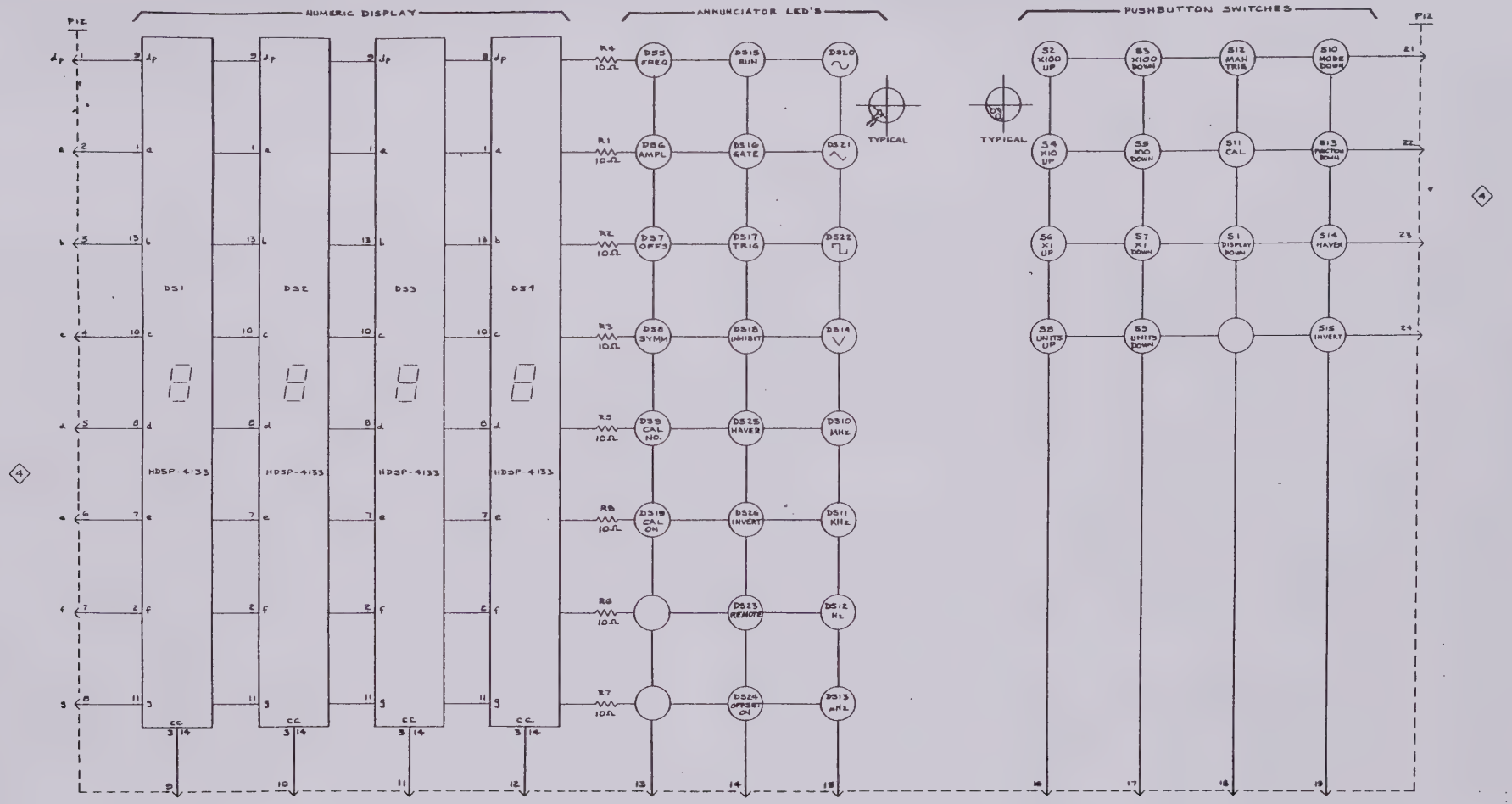
TITLE: PROCESSOR PCB
POWER SUPPLY

SIZE: D
DRAWING NO: 103528-4
REV: A
SCALE:
WEIGHT:
SHT 1 OF 10

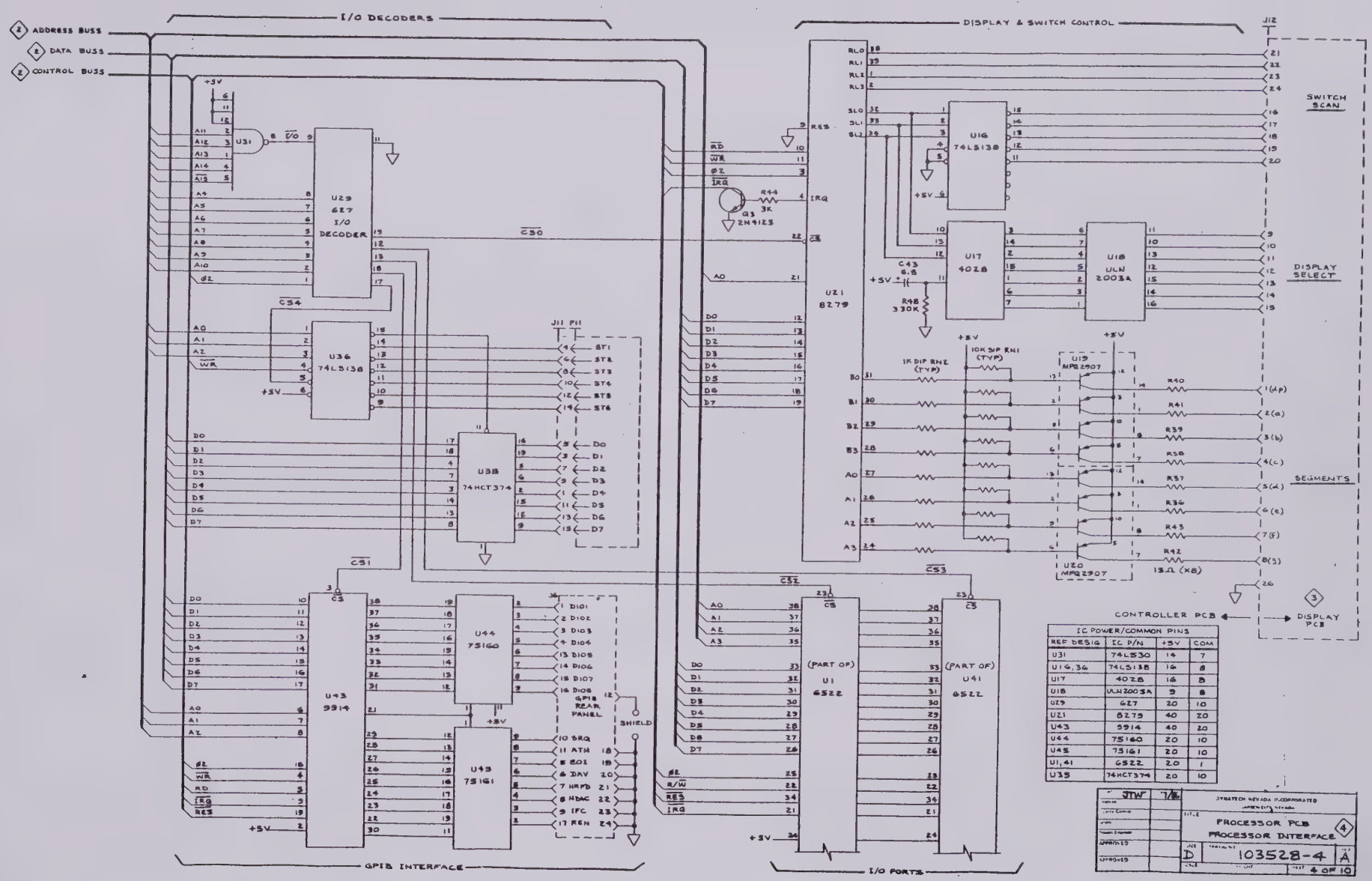


IC POWER/COMMON PINS			
REF. DESIG.	IC P/N	+5V	COM
	74LS00	14	7
U33, 34	74LS04	14	7
U30	74LS139	16	8
U42	6502	8	1, 21
U23, 24, 25	2764	28	14
U26, 27	RAM	24	12
U28	555	8	1
U32	74LS10	14	7

DRAWN	JTW	7/86	SYNERTECH MOVAL & INCORPORATED
CHECKED			TITLE: PROCESSOR PCB PROCESSOR
ENGINEER			SIZE: D
APPROVED			DRAWING: 103528-4
APPROVED			REV: A
			SHEET 2 OF 10

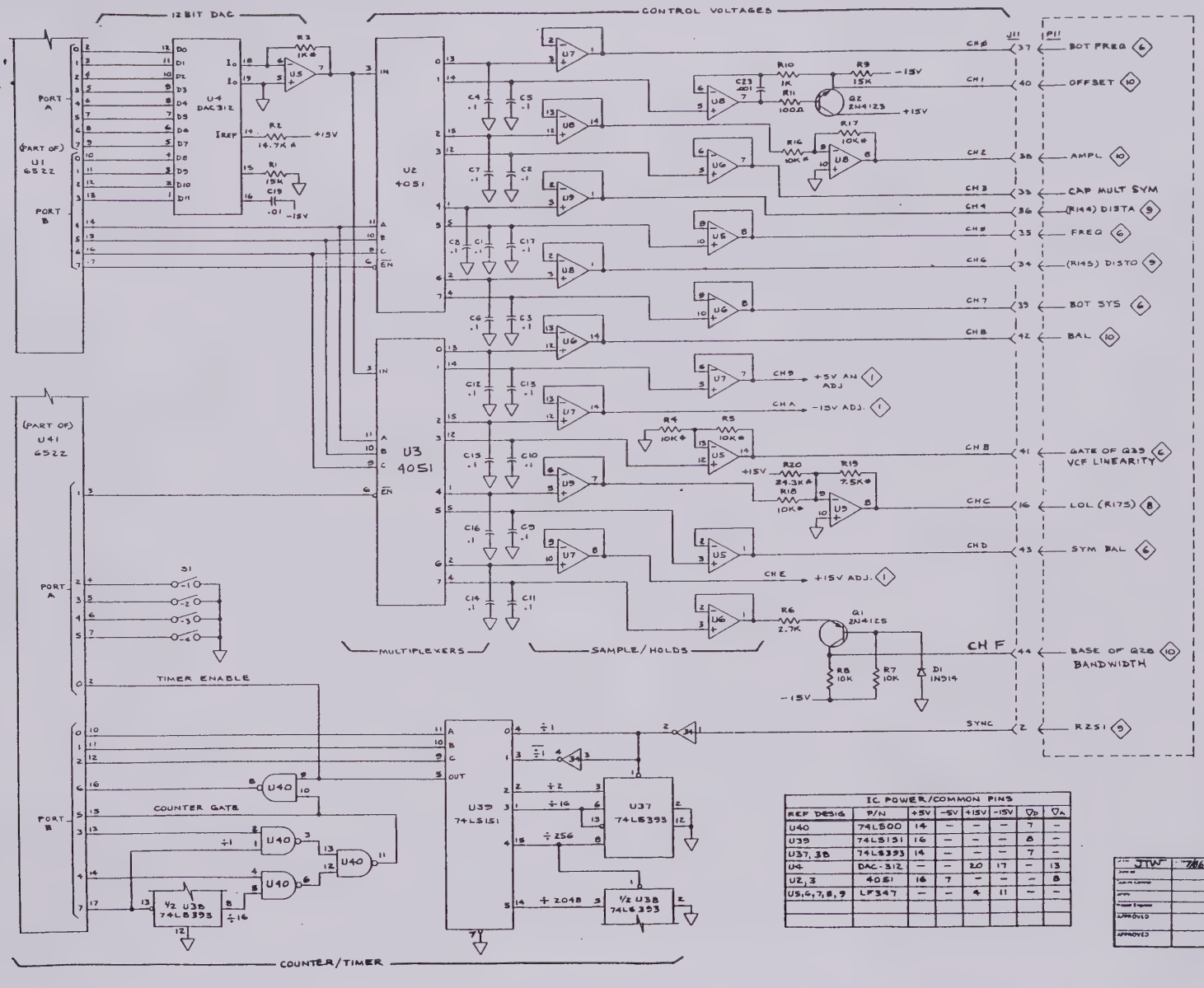


DYNATECH NEVADA INCORPORATED CARSON CITY NEVADA			
TITLE: DISPLAY PCB FRONT PANEL (3)			
SIZE: D	DRAWING NO: 103528-4	REV: A	
SCALE:	WEIGHT:	SHT: 3 OF 10	



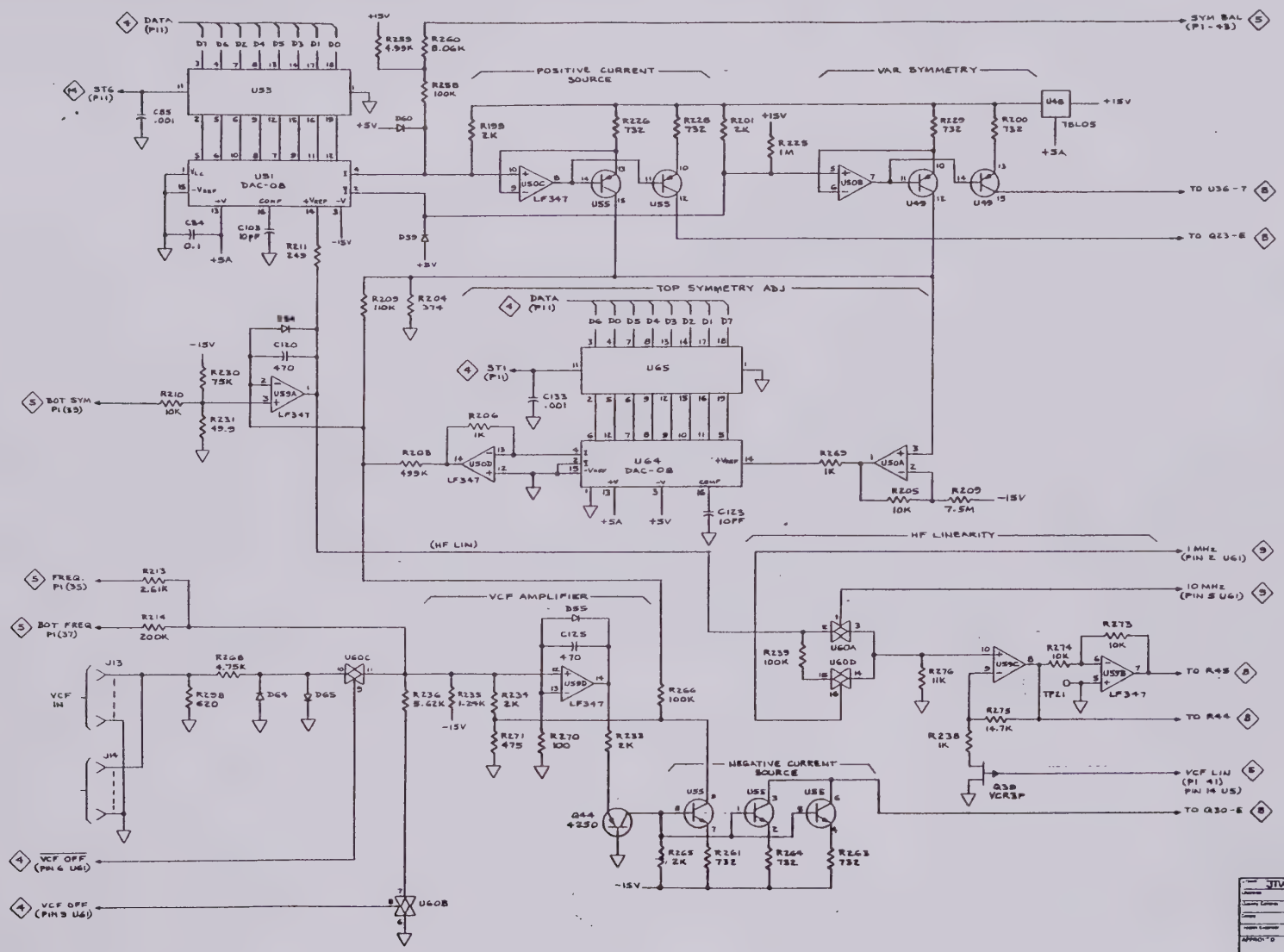
IC POWER/COMMON PINS			
REF DESIG	IC P/N	+5V	COM
U31	74LS30	14	7
U16,36	74LS138	16	8
U17	4028	16	8
U18	ULN2003A	9	8
U29	6Z7	20	10
U21	8279	40	20
U43	9914	40	20
U44	75160	20	10
U45	75161	20	10
U1, 41	6522	20	1
U35	74HCT374	20	10

	JTW	7/86	SYNTECH NEVADA INCORPORATED
TITLE	PROCESSOR PCB PROCESSOR INTERFACE		4
SIZE	D	103528-4	A
		SHEET 4 OF 10	

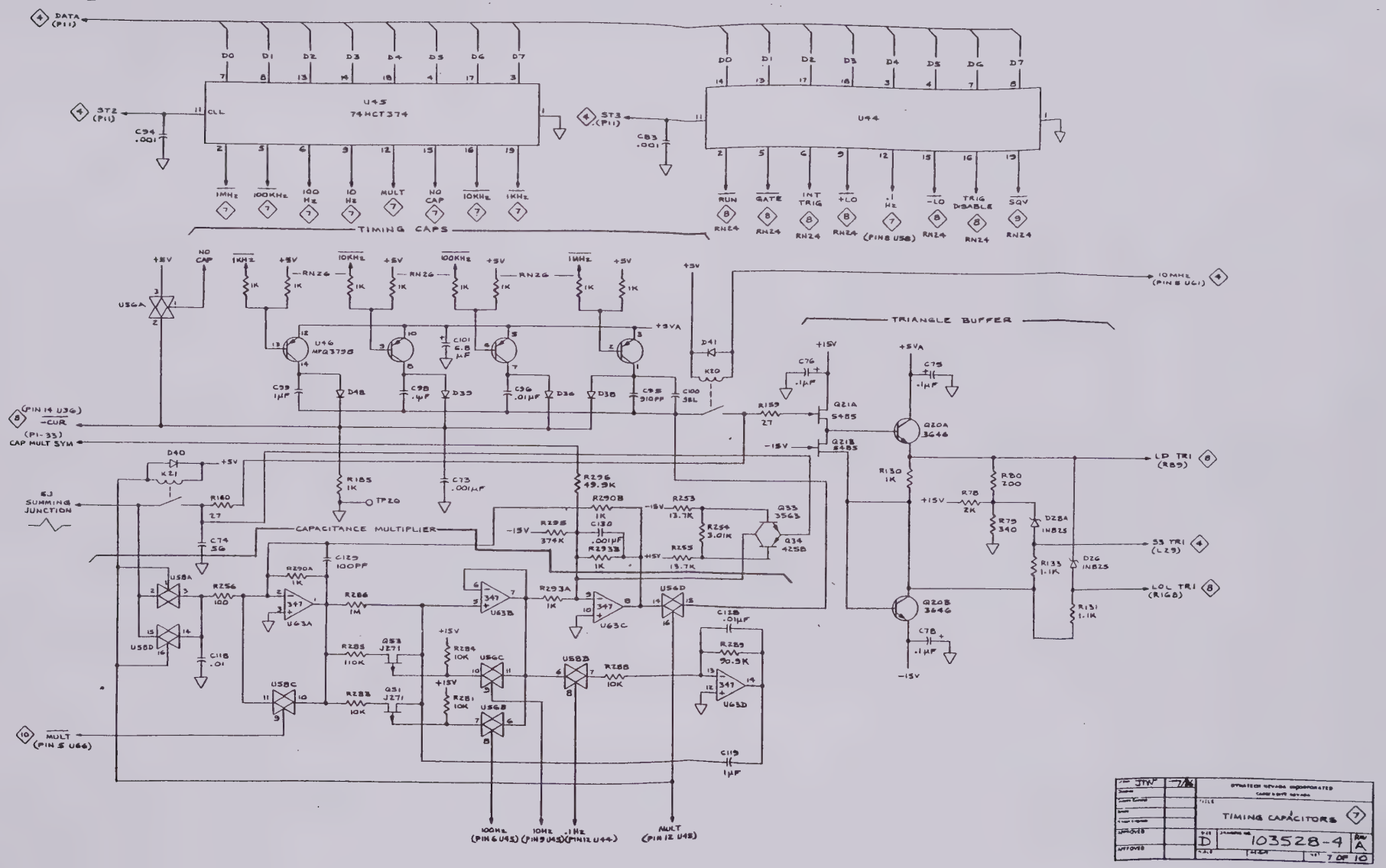


IC POWER/COMMON PINS							
REF DESIG	P/N	+5V	-5V	+15V	-15V	∇_D	∇_A
U40	74LS00	14	–	–	–	7	–
U39	74LS151	16	–	–	–	8	–
U37, 38	74LS393	14	–	–	–	7	–
U4	DAC-312	–	–	20	17	–	13
U2, 3	4051	16	7	–	–	–	8
U5, 6, 7, 8, 9	LF347	–	–	4	11	–	–

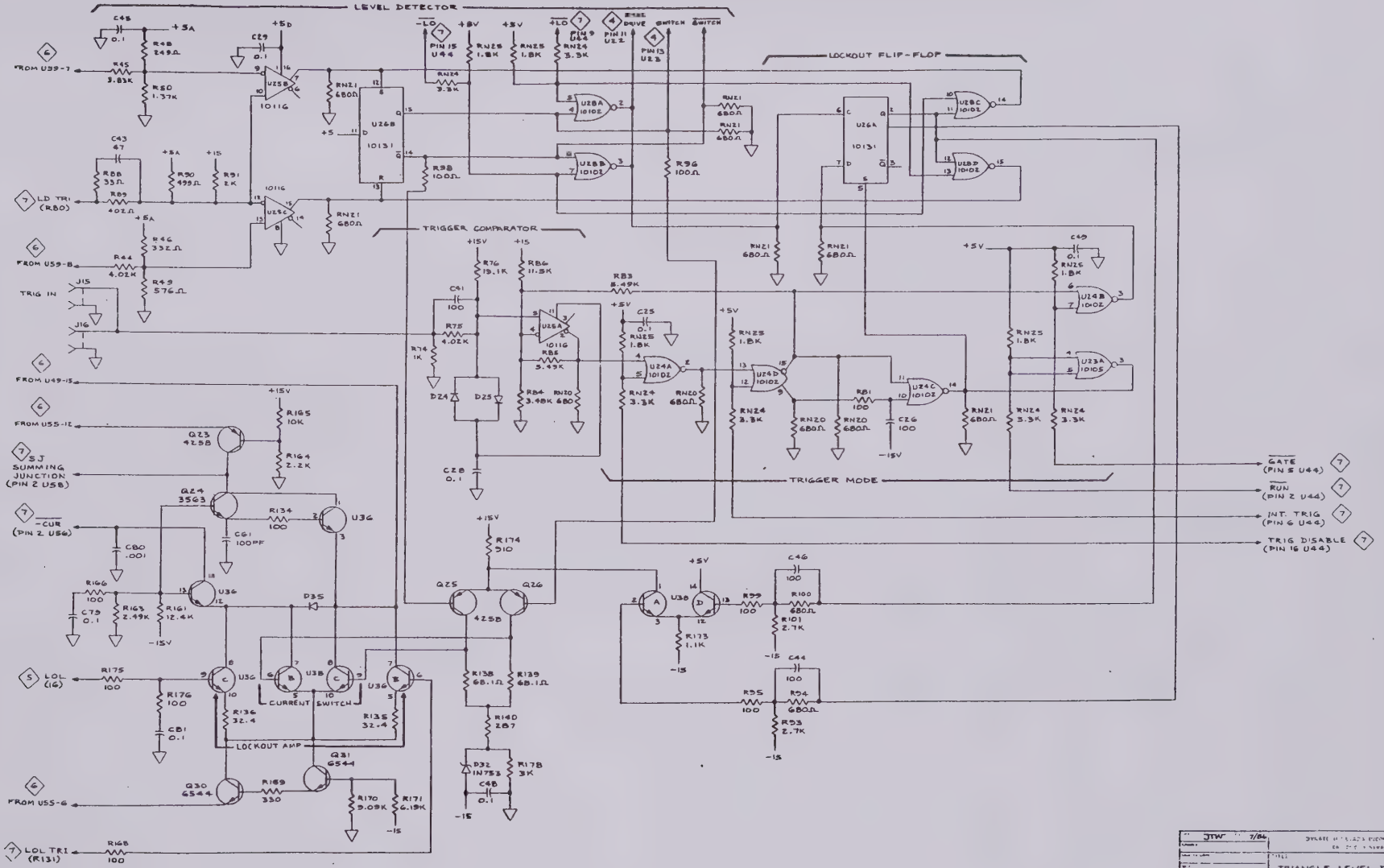
DRAWN JTW	7/86	DYNATECH NEVADA INCORPORATED CARSON CITY NEVADA	
CHECKED		CONTROL VOLTAGES	5
APPROVED		SIZE D	DRAWING NO 103528-4 REV A
APPROVED		SCALE	WEIGHT SHEET 5 OF 10

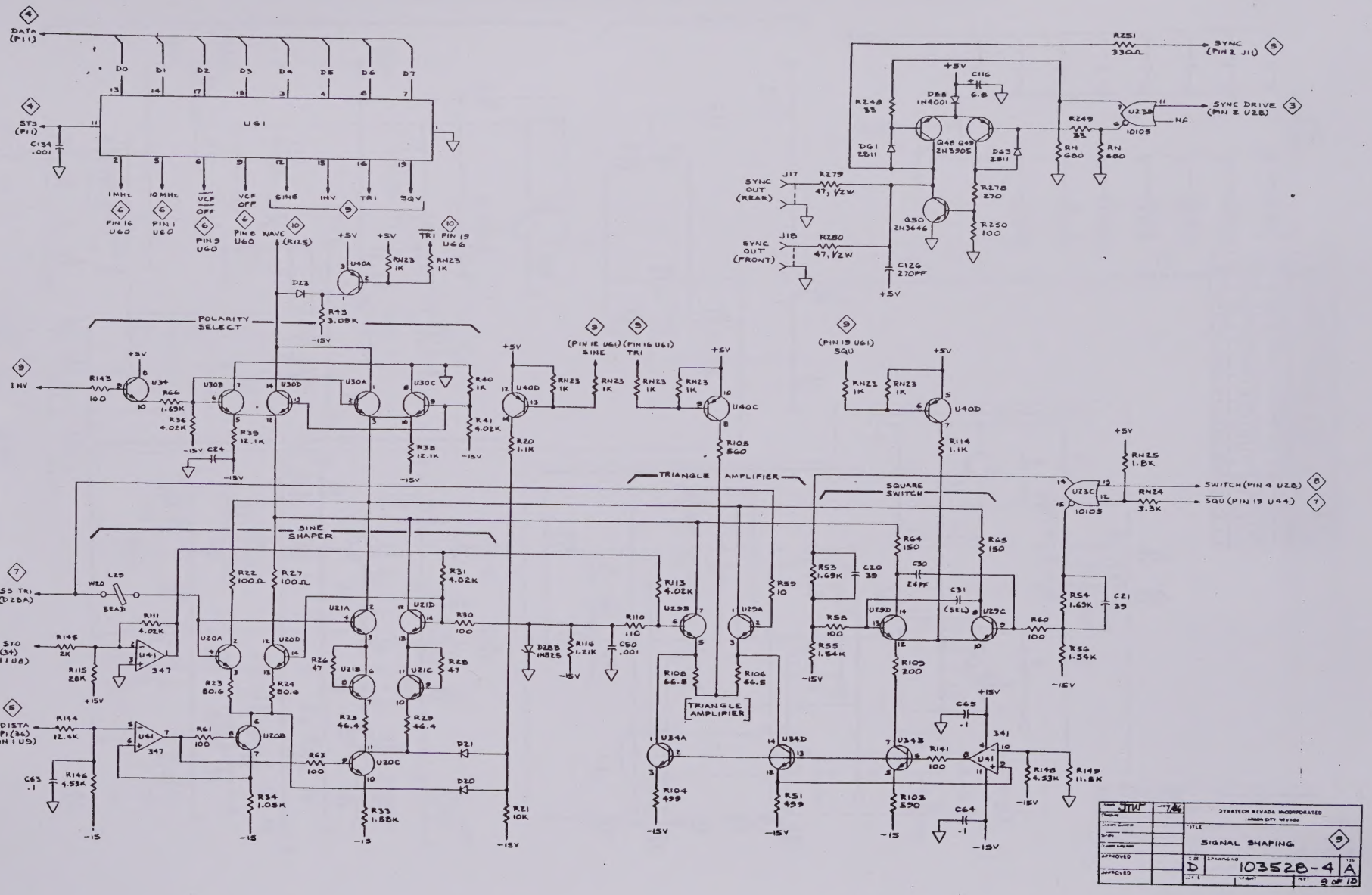


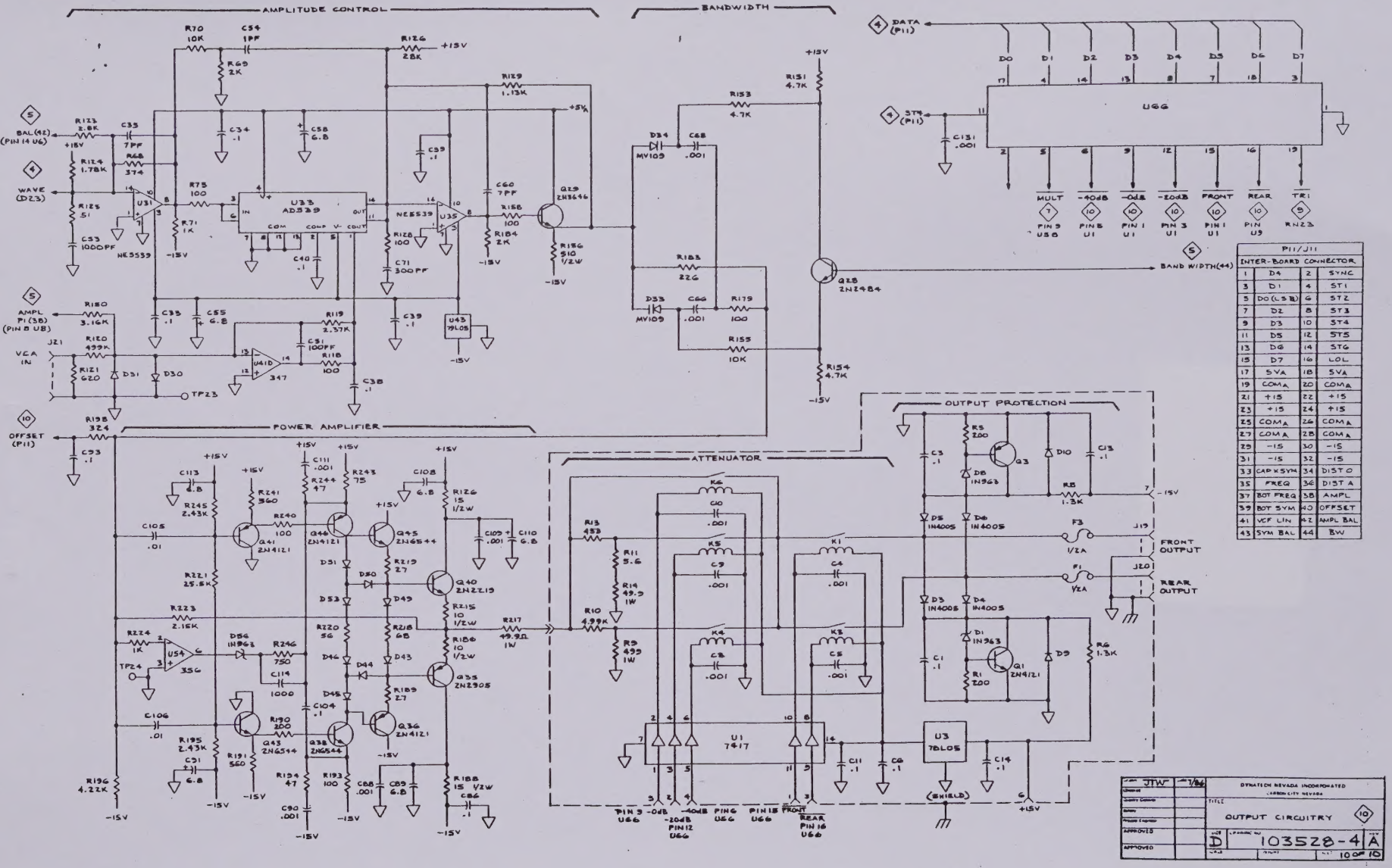
DRAWN JTW	7/82	DYNATECH NEVADA INCORPORATED CARSON CITY NEVADA	
CHECKED		TITLE: CURRENT SOURCES	6
APPROVED		SIZE D	DRAWING NO 103528-4	REV A
APPROVED		SCALE	WEIGHT	SHEET 6 OF 10



DRAWN JTW		SYNTECH NEVADA INCORPORATED	
TITLE	TIMING CAPACITORS		7
SIZE D	DRAWING NO. 103528-4	REV A	
SCALE	SHEET 7 OF 10		


LEVEL DETECTOR
LOCKOUT FLIP-FLOP
TRIGGER COMPARATOR
TRIGGER MODE
LOCKOUT AMP
CURRENT SWITCH
FROM U39-7
LD TRI (R80)
FROM U59-8
TRIG IN
FROM U49-15
FROM U55-12
SJ SUMMING JUNCTION (PIN 2 U58)
-CUR (PIN 2, U56)
LOL (16)
FROM U55-6
LOL TRI (R131)
GATE (PIN 5 U44)
RUN (PIN 2 U44)
INT. TRIG (PIN 6 U44)
TRIG DISABLE (PIN 16 U44)
JTW 7/84
TRIANGLE LEVEL DETECTOR AND LOCKOUT
D 103528-4 A
8 OF 10


DATA (P11)
U61
SYNC (PIN 2 J10)
SYNC DRIVE (PIN 2 U28)
SYNC OUT (REAR)
SYNC OUT (FRONT)
POLARITY SELECT
SINE SHAPER
TRIANGLE AMPLIFIER
SQUARE SWITCH
SWITCH (PIN 4 U28)
SQU (PIN 13 U44)
TRIANGLE AMPLIFIER
SIGNAL SHAPING
10103528-4
A
9 OF 10



P11/J11 INTER-BOARD CONNECTOR			
1	D4	2	SYNC
3	D1	4	ST1
5	D0 (LSB)	6	ST2
7	D2	8	ST3
9	D3	10	ST4
11	D5	12	ST5
13	D6	14	ST6
15	D7	16	LOL
17	5VA	18	5VA
19	COMA	20	COMA
21	+15	22	+15
23	+15	24	+15
25	COMA	26	COMA
27	COMA	28	COMA
29	-15	30	-15
31	-15	32	-15
33	CAP K SYM	34	DIST O
35	FREQ	36	DIST A
37	BOT FREQ	38	AMPL
39	BOT SYM	40	OFFSET
41	VCF LIN	42	AMPL BAL
43	SYM BAL	44	BW

DRAWN JTW	DATE 1/86	DYNATECH NEVADA INCORPORATED, CARSON CITY NEVADA	
TITLE	OUTPUT CIRCUITRY		10
SIZE D	DRAWING NO 103528-4	REV A	
SCALE	SHEET	OF 10	

MP MASTER
MA27969